THE INSTITUTION OF PRODUCTION ENGINEERS JOURNAL

OCTOBER 1957

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PRODUCTION ENGINEERS JOURNAL

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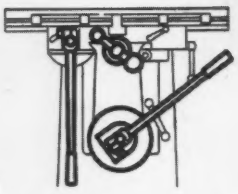

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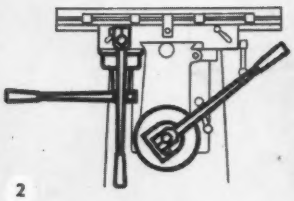

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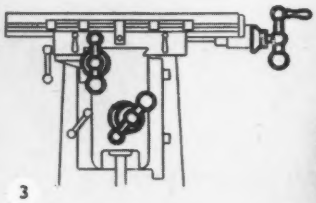
Hand Feed—lever, lever, lever.



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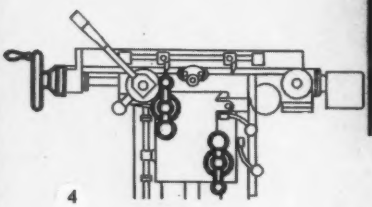

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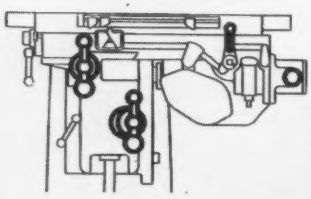
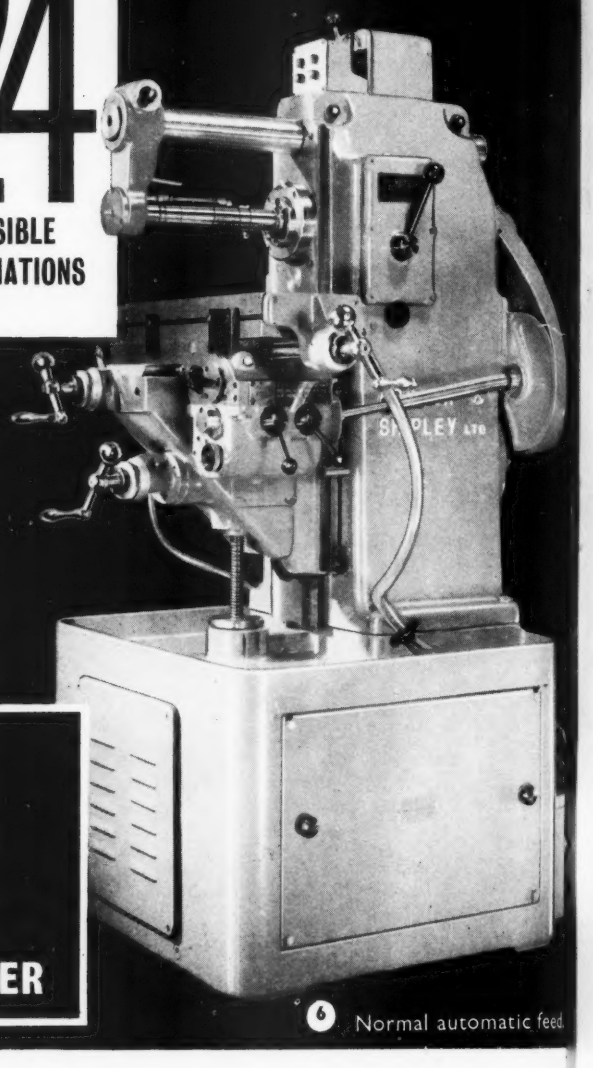


5
Automatic Cycle.

that's the beauty of the

A&S

MODEL 'I' HORIZONTAL MILLER



6 Normal automatic feed

WHY PAY FOR 'SPECIAL' FEATURES YOU MAY NEVER USE?

When you equip with A & S Model '1' Millers you choose from 4 ranges of speeds and 6 different feed arrangements the best combination* for a particular job. Both hand-feed and automatic types can however be supplied with special attachments for special operations. No other small milling machine offers similar versatility or higher production capacity for so wide a range of work.

TABLE 26″ × 7″
LONGITUDINAL TRAVERSE = 10″
VERTICAL TRAVERSE = 10″
TRANSVERSE TRAVERSE = 5½″–6″

**With the A & S Model '1' brochure in front of you, you would know exactly what we mean.*

Built up to a standard–not down to a price

Write for illustrated leaflet

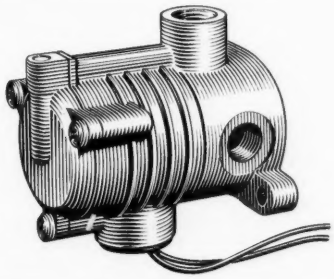
ADCOCK & SHIPLEY LTD

P.O. Box 22, Ash Street, Leicester. Telephone : Leicester 24154-6. Telegrams & Cables : Adcock, Leicester.

You can take Max Am anywhere

As we have said before, the ghostly figure of Max Am symbolises the flexibility and (almost) invisible automatic control exerted by Maxam valves. Max Am is flitting about a good few factories these days; often doing several jobs under one roof. Many of the cars and much of the furniture you see today are produced all the quicker — and cheaper — as a result of Max Am's fluence.

Here and now, Max Am is boosting productivity in 1,000 factories and works up and down the country. Car factories, furniture works, quarries; drilling, moving, loading, ejecting — doing a thousand and one jobs with crisp efficiency, individually or in sequence. Delighted customers reveal that, one way and another, Max Am is responsible for increases in productivity up to 600%. Six hundred per cent, mind you!
There are great savings in maintenance costs too, and more economical use of valuable manpower when Max Am makes his presence felt. There is moreover a further saving: in operating costs. For Max Am works at top pressure, continuously without a lot of care and attention. A tough nut is Max Am. And, as we said, flexible. If you have an operation which you suspect is not as economical as it could be — get Max Am down to have a look at it.



Go-anywhere Max Am

Small, compact, yet immensely robust this Maxam Solenoid Pilot Valve is used for hundreds of different applications in all types of industry, either separately or direct-coupled to Maxam two, three and four-way valves. Wide range of voltages, both A.C. and D.C. Exceptionally long life. High-speed operation.

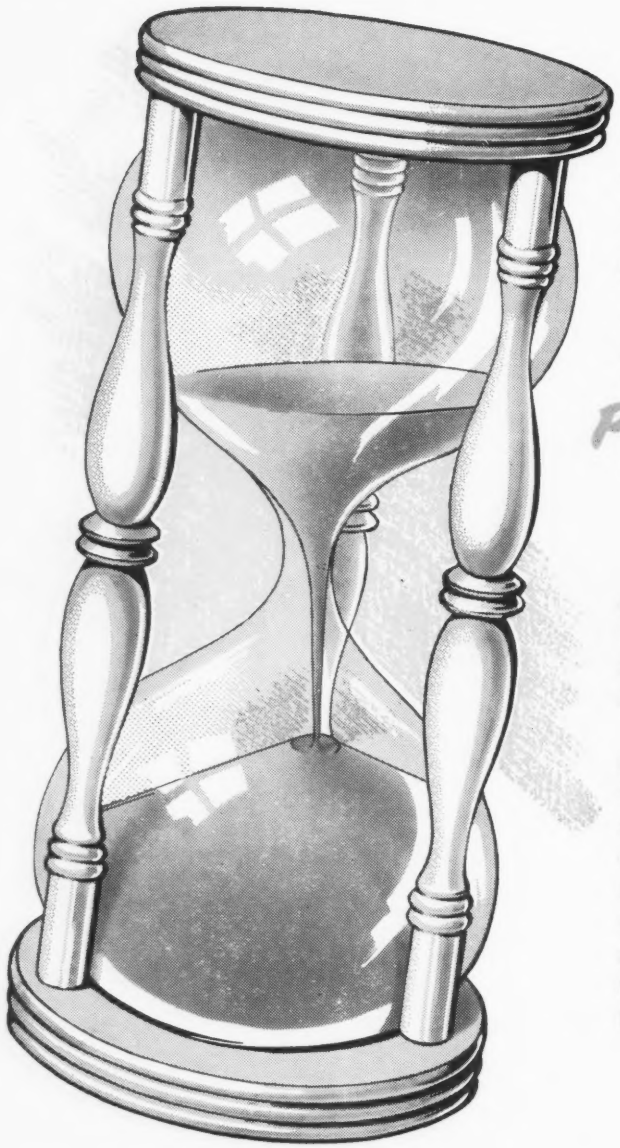
MAXAM

Valves, Cylinders and Airline Equipment

THE CLIMAX ROCK DRILL AND ENGINEERING WORKS LIMITED

Carn Brea, Redruth, Cornwall
Telephone Camborne 2261
4 Broad Street Place, London, E.C.2
Telephone London Wall 5111

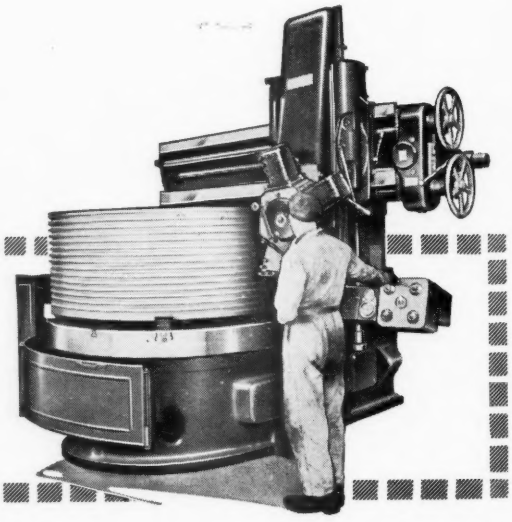
One of the companies of the world-wide Holman Organisation, which has agents, branches and technical representatives throughout the U.K. and in 84 other countries.



A COMPANY IS KNOWN BY THE CUSTOMERS IT KEEPS

Although the world-wide reputation enjoyed by the Webster and Bennett Boring Mill is based on inherent quality and fitness for purpose there are other aspects of service of equal importance.

One of those which is of particular pleasure and satisfaction to our customers, and a source of pride to ourselves, is a punctilious observance of delivery dates. No effort is spared to meet a promised delivery and although unforeseen circumstances have frequently arisen, sufficient in themselves to justify a delivery extension, deliveries quoted for machines have never been broken.



The illustration shows a Webster and Bennett 60″ Boring and Turning Mill at the Bradford Works of Crofts (Engineers) Ltd., machining a 60″ diameter vee groove pulley with a face width of 26″ having 18 grooves 1¼″ wide by 1¼″ deep.

WEBSTER & BENNETT LTD., COVENTRY, ENGLAND

Eliminate TAP BREAKAGE
Increase TAPPING OUTPUT

EQUIP WITH BSA THOMSON. High Speed TAPPING ATTACHMENTS

★ Previously known as the Thomson. Now made by B.S.A. Tools Limited.

STANDARD MODEL

Colour coded for each tap size. Head is quickly and easily indexed to appropriate colour position for correct tap-driving pressure.

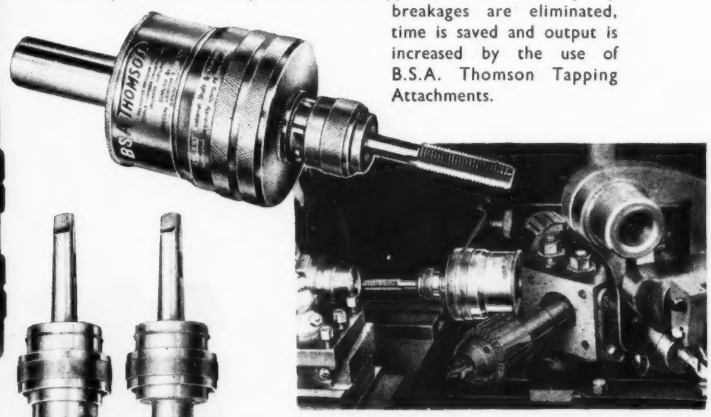
High-grade steel body.
All moving parts precision finished.
No intricate mechanism to go wrong.
No external projections.

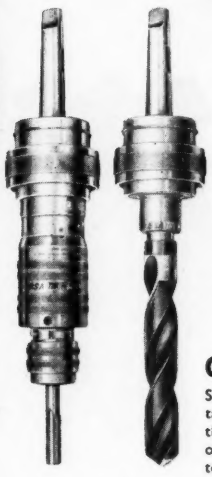
Each Standard or Combination model covers a wide range of standard hand taps.

T1 : ½" to 1¾" W. MTS 4 or 5
T2 : ⅜" to 1¼" W. MTS 3, 4 or 5
T3 : 3/16 to ½" BSF. MTS 2 or 3

410

In the B.S.A. THOMSON a cushion of material 150 times the resiliency of spring-steel provides sufficient tap-driving torque for tapping and ample reserve elasticity to relieve the tap of extreme stresses should it encounter an obstruction or the bottom of a blind hole. A quick and easy pre-setting of the head ensures the correct tap-driving pressure for any diameter irrespective of the type of material. Costly tap breakages are eliminated, time is saved and output is increased by the use of B.S.A. Thomson Tapping Attachments.





FOR CAPSTAN & TURRET LATHES

Fit directly into turret socket without sleeves or adaptors. Mate perfectly with other turret tools. For standard hand taps — Model CP2: ⅜" to 1" W. or ANC. Model CP3: 3/16" to ½"

COMBINATION MODEL

Supplied with a master holder to fit the machine spindle. The tapping attachment can be withdrawn from the Holder while the spindle is running. Drilling, reaming, countersinking and other operations can be performed by inserting the necessary tool into the adaptor and loading into the Master Holder.

B.S.A. TOOLS LTD · BIRMINGHAM 11 · ENGLAND

Sole Agents Great Britain: Burton Griffiths & Co. Ltd., Small Tools Division Montgomery Street, Birmingham, 11. Telephone: VICtoria 2351/9

today's cutting tools are *different*

Madame La Guillotine might have had the edge on cutting tools in 1789, but today, things are different. Take Cutanit for example, the cutting tool with a real difference — a difference which enables it to retain its original accuracy over exceptionally long periods. Consequently, Cutanit cuts costs on tool purchase, re-grinding and re-setting. Cutanit is available in a standard range of tools and tool-tips for cutting steel, non-ferrous and non-metallic materials. It is also supplied to customers' specifications. Please send for a copy of our monthly stock list.

Cutanit

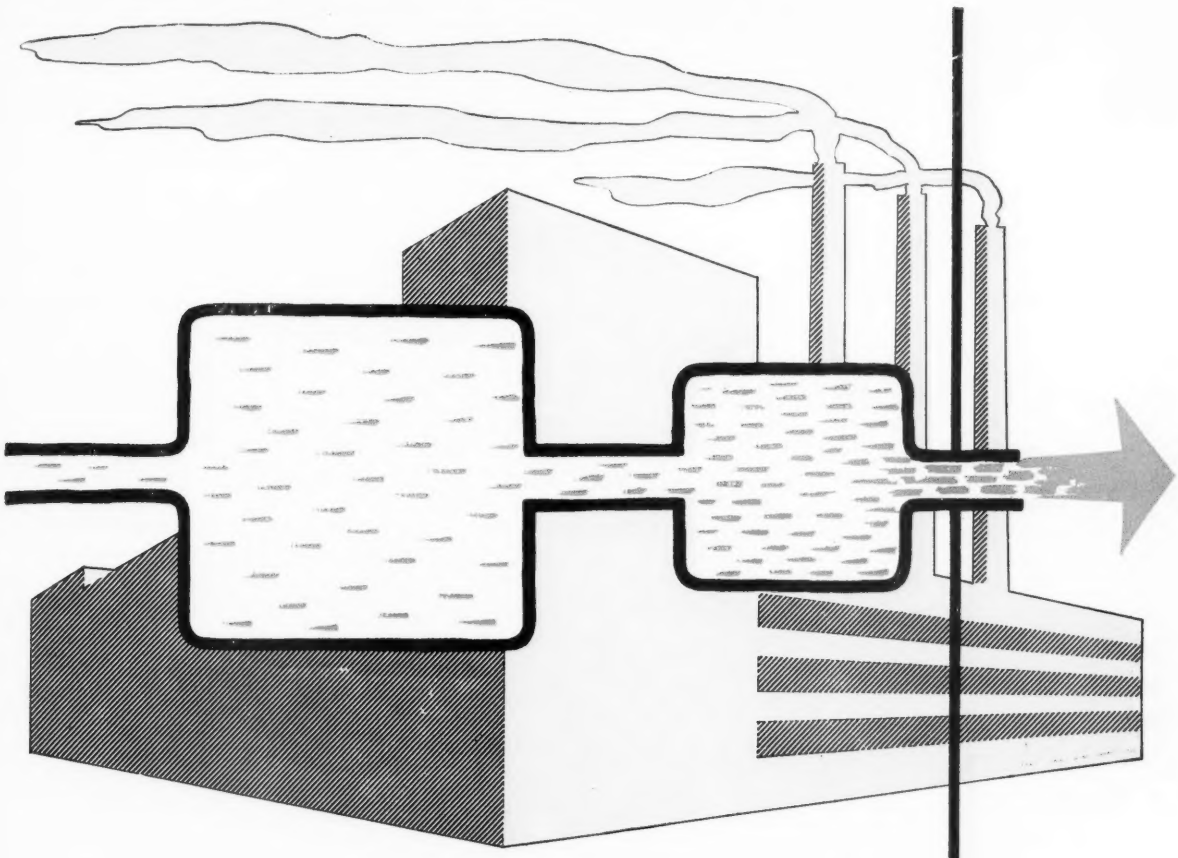
A METRO-CUTANIT PRODUCT

CEMENTED CARBIDE

WM JESSOP & SONS LTD
BRIGHTSIDE WORKS SHEFFIELD

J J SAVILLE & CO LTD
TRIUMPH WORKS SHEFFIELD

ALL ENQUIRIES TO: SMALL TOOL WORKS PORTLAND ST SHEFFIELD 6 · TELE 20224

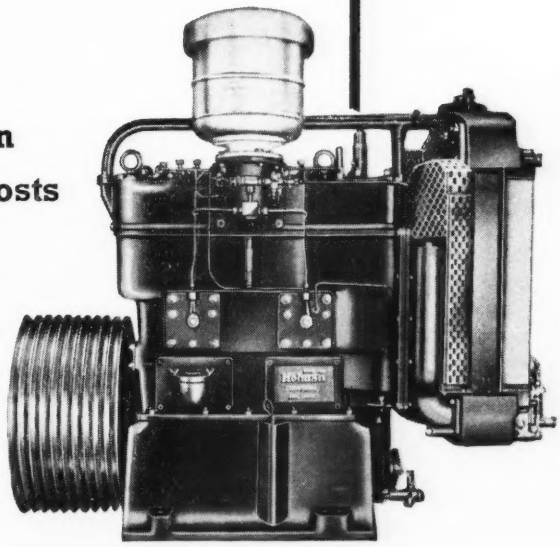


High output from low power
Holman 2-stage air-compression
cuts wear and tear — running costs

Here's efficiency for you ! By using the most practical method of air compression — two-staging — the maximum volume of air is compressed for a given power.

Here's economy, too. For you'll not have trouble with this air compressor. Long life is built-in; running cost is cut to rock bottom. And it's running cost that is the *real* cost of an air compressor.

Get a Holman and you've got the toughest, most efficient *money-saving* air compressor you'll find.

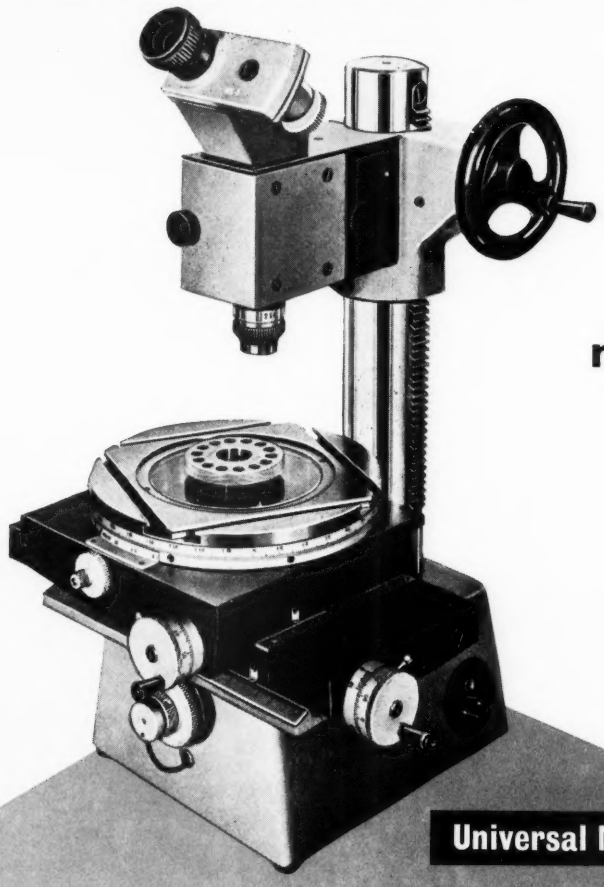


Holman
PNEUMATIC EQUIPMENT

pays . . . with its life

HOLMAN BROS. LTD., CAMBORNE, ENGLAND
The Holman Organisation is world-wide. It includes the Climax Rock Drill & Engineering Works Ltd., and has agents, branches and technical representatives throughout the United Kingdom and in 84 other countries.
Telephone: Camborne 2275 (10 lines). Telegrams: Airdrill, Telex, Camborne. London Office: 44 Brook Street, W.1. Telephone: Hyde Park 9444

HJ17



made to measure

. . . in all workshops

Universal Measuring Support Type U-10

Precision-built, versatile and mobile, the U-10 Measuring Support with its wide range of accessories brings to even the smallest workshop the assurance of speedier, more accurate inspection of machined parts.

Universal scope The U-10 Support is used for measuring flat and cylindrical parts, balls and diameters of threads by comparison with a standard or reference gauge. Accessories permit inspection of angles and thread profiles, vertical measurement in absolute value and measurement in rectangular and polar co-ordinates in a horizontal plane.

Portable Lightweight and of compact design, the U-10 Support presents no transport problems. It sits easily on the inspection bench and can be quickly moved from workshop to workshop. The U-10 Measuring Support is one of several measuring instruments in the manufacturing programme of Société Genevoise d'Instruments de Physique.

Others are:

MUL-1000, MUL-3000 and MUL-4000 Universal Measuring Machines of 1, 3 and 4 metre linear capacity.

MUL-250 Shop Gauge Measuring Machine.

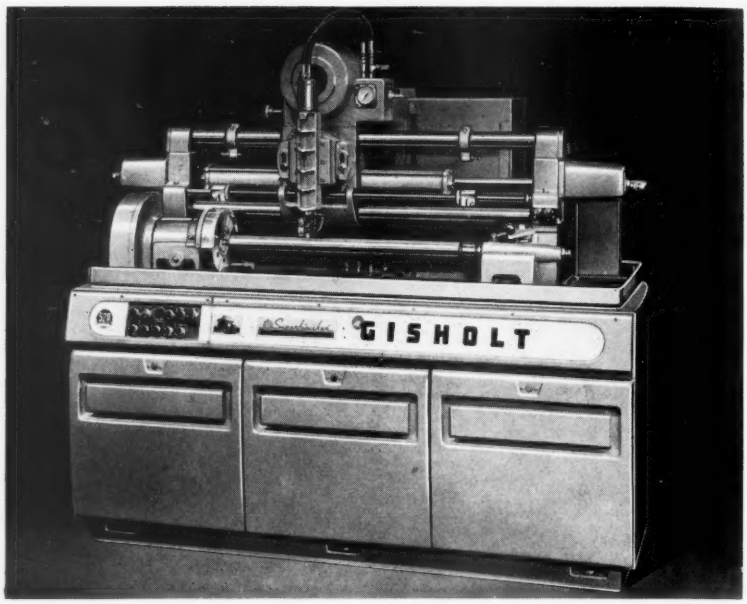
MU-214B Three Co-ordinate Universal Measuring Machines.

Detailed information about S I P Measuring Machines is available from Société Genevoise Ltd., Newport Pagnell, Bucks. Telephone: Newport Pagnell 460/1/2. Telegrams: SIP Newport Pagnell.

Measuring Machines by SIP

the Measure of Measures

In the Gisholt SUPERFINISHING machine, as the work rotates it is subjected to a light-pressure contact of an oscillating abrasive stone. This imparts a scrubbing effect which removes minor surface irregularities such as chatter and feed marks and "smear" metal surface left by the usual grinding operation. Surface finishes of one micro-inch can be quickly and economically attained by Superfinishing.



Gisholt General Purpose Superfinisher Model 52A is shown for work up to 10" swing, 36" between centres, maximum weight 125 lb. The No. 3 Superfinishing Attachment is designed for tool post mounting on engine or turret lathes; for work up to 9" diameter.

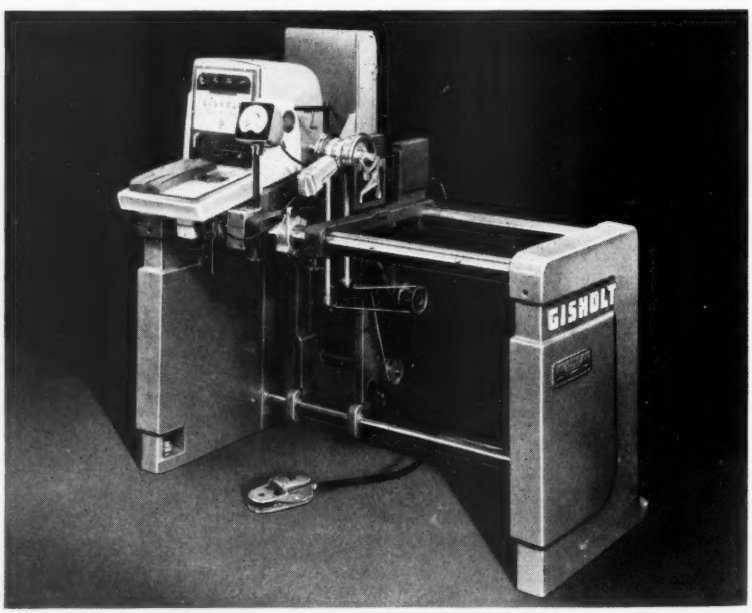
SUPERFINISHING MACHINES

GISHOLT

BALANCING MACHINES

SPECIFICATIONS	HORIZONTAL—FLOOR TYPE			
	1S	13S	3S	31S
Work Capacity, Weight in lbs.	1-30	2-50	15-300	2-300
Overall Diameter	12"	24"	24"	24"
Shaft Diameter at Bearing Surfaces	1¼"	2¼"	5"	2¼" & 5"
Maximum Distance Between Bearings	12"	24"	24"	24"
Balancing Speeds, R.P.M.	1000-3000	1000-2000	1000-2000	1000-2000
Floor Space (Approx.)	43"x43"	68"x43"	68"x43"	68"x43"
Net Weight, lbs. (Approx.)	1500	1700	1800	1900

Gisholt DYNETRIC Type S Balancing machines provide a means for quickly and accurately measuring and locating unbalance in parts weighing from a few ounces to several hundred pounds. They are equally suitable for either large or small quantities of similar parts. The required amount of correction to balance is indicated in practical units such as in thousands of an inch depth of drill, in 1/64 inch lengths of wire solder, or in any other units most satisfactory for the specific workpiece.



BRITISH BUILT

BALANCING MACHINES
SUPERFINISHING MACHINES

Gisholt Machine Company of Madison, Wisconsin, U.S.A., announce the formation of a subsidiary company for the manufacture in Great Britain of certain machines and equipment in their range.

The decision to form the new company has been brought about by the differential between manufacturing costs in the United States and Europe, and international fiscal policies which for sometime have made it difficult for European customers to exercise their preference for Gisholt machines.

Known as Gisholt Machine Company (Great Britain) Limited, the new company has offices in London with Albert E. LaGrille, Managing Director, and Hobart S. Johnson II, Director and General Manager.

Both the United States and British Companies will continue to be represented in the United Kingdom by Burton, Griffiths and Company Limited, and Gaston E. Marbaix Limited, who have held their representation for sixty and eleven years respectively.

GISHOLT MACHINE COMPANY
1245 East Washington Avenue,
Madison 10,
Wisconsin, U.S.A.

GISHOLT MACHINE CO. (GREAT BRITAIN) LTD
93 Albert Embankment,
London, S.E.11.
'Phone RELiance 4771/2.

October, 1957

●

BURTON, GRIFFITHS
& CO. LTD.
Kitts Green, Birmingham 33.
'Phone STECHFORD 3071

GISHOLT—

BALANCING MACHINES

COMBINATION TURRET LATHES

SIMPLIMATIC LATHES

HYDRAULIC PRODUCTION LATHES

●

GASTON E. MARBAIX LTD.
Devonshire House,
Vicarage Crescent,
London, S.W.11.
'Phone BATTERSEA 8888

GISHOLT—

SUPERFINISHING MACHINES

FASTERMATIC LATHES

●

In the production of these insulated shrouds and for potting transformers, South Wales Switchgear Ltd. use 'Araldite' casting resins. For every branch of electrical engineering, 'Araldite' offers advantages which make it invaluable. These include remarkable adhesion to metals and ceramics, excellent electrical properties, stability and resistance to moisture. The two units illustrated are an insulated shroud for a 33kV switchgear earthing device and a 3-phase voltage transformer, ratio 6600/110V, 200VA.

Earth... and potting

'Araldite' epoxy resins have a remarkable range of characteristics and uses:

They are used

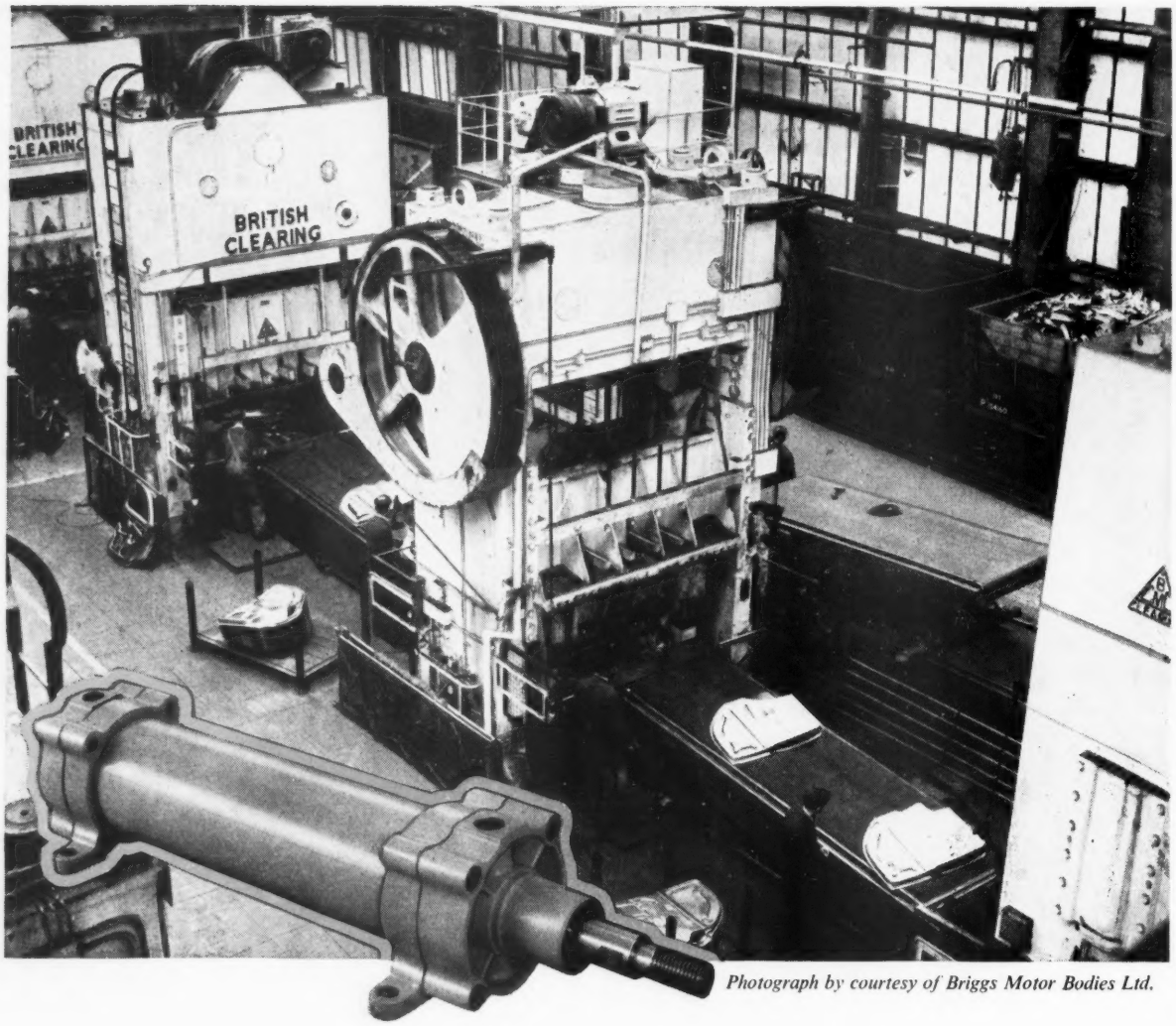
- **for bonding metals, porcelain, glass, etc.**
- **for casting high grade solid insulation**
- **for impregnating, potting or sealing electrical windings and components**
- **for producing glass fibre laminates**
- **for producing patterns, models, jigs and tools**
- **as fillers for sheet metal work**
- **as protective coatings for metal, wood and ceramic surfaces**

'Araldite' **epoxy resins**

'Araldite' is a registered trade name

Aero Research Limited *A Ciba Company. Duxford, Cambridge. Tel: Sawston 2121*

AP. 264-233



Photograph by courtesy of Briggs Motor Bodies Ltd.

'Fescol'-ised Air Cylinders help to keep Production Moving

The air cylinders supplied by Baldwin Instrument Co. Ltd., to provide power operation for automatic work handling devices, have 'Fescol'-ised bores and piston rods to reduce friction and ensure maximum life from seals. This is one further example of the way in which Fescol, who pioneered the electro-deposition of nickel and chrome for engineering purposes, still lead the way, adapting their process to help each new industrial development.

If you would like to know more about the process, and its use in preventing corrosion and protecting new machinery please send for publication No. PE5.

FESCOL

Established 1920

FESCOL LIMITED · NORTH ROAD · LONDON N 7

BRANCH WORKS AT PORT GLASGOW, HUDDERSFIELD AND BROWNHILLS

Sole Licensees for Australasia: De Havilland Aircraft Pty. Ltd., Milperra Road Bankstown, N.S.W

TGA 158

Covering Every Field -

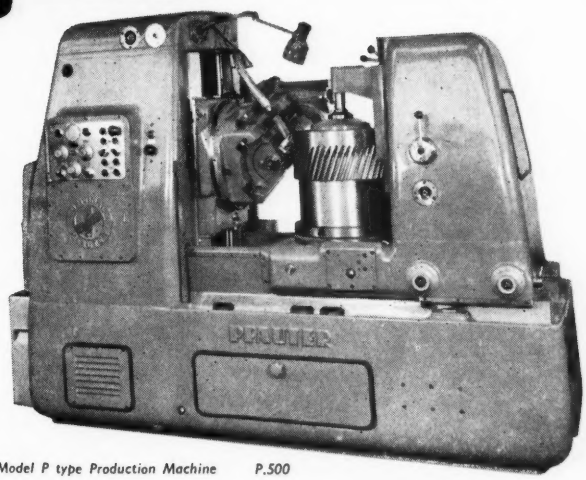
OF GEAR AND SPLINE HOBBING

The unparalleled range of

Original Pfauter hobbers

meets every manufacturing need.

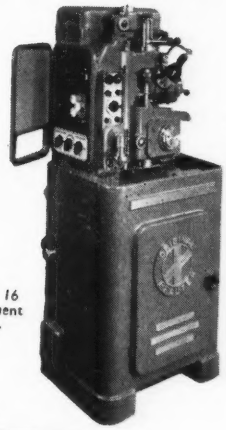
May we forward literature ?



Model P type Production Machine P.500

Original PFAUTER Hobbers

FOR *PACE* · POWER · PRECISION



Model R 16 for Instrument Gears.

MANUFACTURING PROGRAMME

Vertical Work Mounting

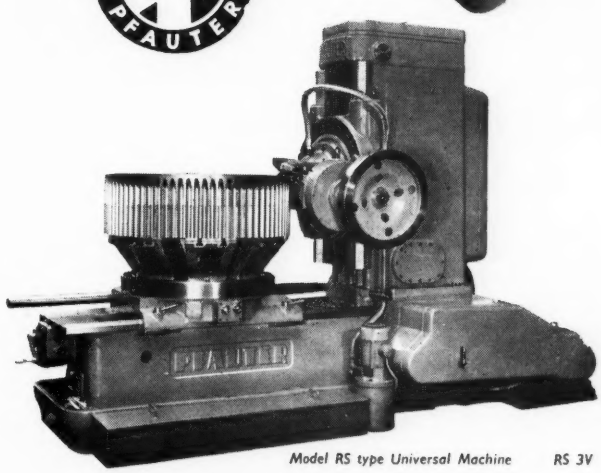
Pfauter Type No.	Max. Gear dia. ins	Max. Gear width ins.	Max. DP
R 16	$3\frac{1}{8}$	2	25
RS 00	10	$6\frac{1}{2}$	10
P 250	10	$6\frac{1}{2}$	7
DRA DUPLEX	10	10	3
P 400	$15\frac{3}{4}$	$11\frac{3}{4}$	$4\frac{1}{4}$
P 500	20	14	3
RS 1V	$29\frac{1}{2}$	$12\frac{1}{2}$	3
P 900	$35\frac{1}{2}$	15	3.2
RS 2V	$39\frac{1}{2}$	$14\frac{1}{2}$	$2\frac{1}{2}$
P 1250	$49\frac{1}{2}$	$19\frac{3}{4}$	2.1
RS 3V	71	21	$2\frac{1}{2}$
P 1800	71	$24\frac{3}{4}$	$1\frac{3}{8}$
P 2500	100	$24\frac{3}{4}$	$1\frac{3}{8}$

Horizontal Work Mounting

P 160	7	$13\frac{1}{2}$	6
RS 9K	$11\frac{1}{2}$	27	$2\frac{1}{2}$

Worm and Thread Milling Machines

SF 1	$11\frac{1}{2}$	27	$1\frac{3}{4}$ CP



Model RS type Universal Machine RS 3V

VAUGHAN ASSOCIATES LIMITED

4 QUEEN STREET · CURZON STREET · LONDON, W.1. · Telephone: GROsvenor 8362-5.

Midland Office: Wilford Crescent, Nottingham. Telephone: Nottingham 88008.

CERAMIC CUTTING TOOLS

The wide publicity given to cemented oxide cutting tools during recent months has promoted the belief in some quarters that a new metal-cutting medium of astronomical potential is now available.

Although such tools were demonstrated by Wickman Limited at the International Machine Tools Exhibition in 1956, after development work extending over many years, it has always been realised that severe limitations to further research and development are imposed by the lack of machine tools capable of extending their known high-speed machining characteristics to the ultimate.

Experience with cemented oxide tools already gained suggests that where very high speeds can be applied with relatively light cutting pressures, satisfactory performances can be achieved sometimes comparable with those being regularly obtained with cemented carbides.

In an endeavour to discover the natural field of application for cemented oxides and the techniques of tool geometry, speeds and feeds, and the potential metal removal ratings, this Company has now begun a new programme of tests. New machine tools of advanced experimental design have been specially built and are now being installed for this purpose. We think these tests will provide conclusive evidence of the fields of application of most economic benefit and we shall look forward to keeping industry informed of their progress.

In the meantime, we are prepared to supply cemented oxide tips in a limited range of shapes to cutting tool users who may wish to test for themselves the possibilities of the material, and who may possess suitable machines for this purpose.

WICKMAN LIMITED.

The Institution of Production Engineers Journal
VOL. 36 NO. 10 OCTOBER, 1957

What About The Small Firm?

A Paper presented at the
Second Plenary Session of the Harrogate Conference
by E. W. HANCOCK, M.B.E.,
M.I.Mech.E., Hon.M.I.Prod.E., F.I.I.A., F.R.S.A.

Mr. Hancock, who is the immediate Past President of the Institution is Director and General Manager of the Humber Company, Coventry—the Car Production Division of the Rootes Group.

HOW frequently is heard at lectures and discussions in various parts of the country the question : " What about the small firm ? ".

This question usually follows a lecture on some new layout or installation of a modern machine or piece of plant, or some new Training Centre at a large works, or a lecture on Operational Research, Work Study, etc., etc.

Whatever the new interest is which is being discussed, it is usually large, expensive, dramatic or involves a difficult-to-understand new name.

Well! What about the small firm and this Conference on " Automatic Production — Change and Control ? ". Does the small firm come in and, if so, where ?

The answer without any doubt to the first question is " Yes ", and to the second question, " Everywhere ".

The word FIRM is used in the title and the word is very apt as applied to this particular subject, as amongst many descriptions one can find in a dictionary, the following definition has been chosen — " A partnership in business " (Nuttall's).

The importance of the small firm is without question, and in order to give sufficient scope of interest to this subject, the following nine headings have been selected :-

1. General figures relative to this country.
2. Inter-relation between small and large firms.
3. The basic difference in various sized firms.
4. The approach and methods.
5. The relationship between Trade Unions and national agreements, the Factory Acts and general welfare.
6. What the small and large firms can learn from each other
7. The main features which govern both.
8. The human factors including training and education of young people.
9. General summary relative to the Conference theme.

1. General Figures Relative to this Country

First of all, it has to be established what is meant by a " *SMALL FIRM* ". It is felt that this should be based on the number of people employed. I want to emphasise that I mean small in size, but by no means small in importance.

The selection of the number has been based on 100 people or less as representing a small firm.

The Charts, 1 and 2, which follow, set out basic figures which are self-explanatory.

SMALL FIRMS IN INDUSTRY

AS AT JANUARY 1956
SOURCE: ANNUAL ABSTRACT OF STATISTICS 1956
PUBLISHED BY HER MAJESTY'S STATIONERY OFFICE

No. of Employees Working in an Establishment	No. of Establishments	% of Total Establishment	No. of Employees Employed by all Establishments	% of Total Employed
11— 24 Employees	15,509	27%	270,000	3.4%
25— 99 Employees	25,830	46%	1,285,000	16.3%
11— 99 Employees	41,339	73%	1,555,000	19.7%
100— 499 Employees	12,178	22%	2,543,000	32.2%
500— 999 Employees	1,667	3%	1,151,000	14.6%
1,000—1,999 Employees	722	1.3%	1,012,000	12,8%
2,000 and Over	407	0.7%	1,627,000	20.6%
100 Employees and Over	14,974	27%	6,333,000	80.3%
TOTAL	56,313	100%	7,888,000	100%

CHART 1

Trade	Total Establishments	Establishments Employing:—under 100					
		11—24 Employees		25—99 Employees		11—99 Employees	
		No.	% of Total	No.	% of Total	No.	% of Total
Treatment of Mining Products except Coal	2,611	585	22%	1,330	51%	1,915	73%
Chemicals	2,239	528	24%	923	41%	1,451	65%
Metal Manufacture	1,915	314	16%	751	39%	1,065	55%
Engineering, Shipbuilding and Electrical Goods	8,886	2,210	25%	3,772	42%	5,982	67%
Vehicles	5,672	2,099	37%	2,522	45%	4,621	82%
Precision Instruments and other Metal Goods	5,708	1,665	29%	2,742	48%	4,407	77%
Textiles	6,210	1,002	16%	2,770	45%	3,772	61%
Leather, Leather Goods and Fur	930	316	34%	466	50%	782	84%
Clothing (inc. Footwear)	6,254	1,823	29%	3,156	50%	4,979	79%
Paper and Printing	4,334	1,273	29%	1,995	46%	3,268	75%
Food, Drink and Tobacco	6,070	1,990	33%	2,670	44%	4,660	77%
Wood and Cork Manufacture and Misc.	5,484	1,704	31%	2,733	50%	4,437	81%
Total	56,313	15,509	27%	25,830	46%	41,339	73%

CHART 2

It will be noted that out of the 56,313 firms registered in accordance with Her Majesty's Annual Abstract of Statistics, no less than 41,339 employ 100 people or less. This shows that 73% of our factories are "small firms".

It is interesting to find that 27% of the firms employ 50 people or less, while those employing 500 people or less represent 95% of the firms of this country. Taking figures of employment, we find that the 41,000 odd firms employing 100 people or less employ 19.7% of the total employed population of between eight and nine million, but the firms employing 500 or less employ no less than 52% of the total.

In the second chart I have tried to pick out the main industries, so that it can be seen where these small firms are, the type of work which they do, and how wide spread is the base.

2. Inter-Relation Between Small and Large Firms

In the first case, we must establish the importance of the small firm as a base on which the large firm stands. The small firm is somewhat like the base of a pyramid or triangle with the large firms at the apex and the small firms forming the base.

Even with large firms having their own groups it will be found that they are also in the shape of a triangle, relying entirely for many of their specialist supplies from the small firms in their own groups.

All sized firms, large or small, are completely interrelated and absolutely dependent one upon the other. The " apex " is no good without the " base."

The build-up is similiar to a coral reef where only the peaks show above the " water line." There are many well-known firms above the " water line," but underneath is the large percentage of small firms which have little industrial " limelight." These small firms are doing work which is absolutely essential to the large firm and, of course, to the national economy.

The simile is not exactly correct as, unlike the coral reef, the small firms under water, as it were, are very much alive and very virile in their flexibility in responding to the demands and requests of the larger firms. For example, in the motor industry in this country, reference is made from time to time to the " Big Six," namely the large well-known motor car firms, but very rarely do we hear of the " little 4000 " firms who supply the " Big Six " with their specialised requirements.

It is important to appreciate that the pattern in Great Britain relative to factory size is similar to that in the U.S.A., where they, too, have a large percentage of small firms.

In the U.S.A., the small firm or business, as they call it, is so important that there is a Government interest which helps the small business concerns to compete with the larger firms.

An Act was passed in 1953 which states that:

> " It is the declared policy of the Congress that the Government should aid, counsel, assist and protect as far as possible the interests of small business concerns "

and the S.B.A. (Small Business Administration) was set up to implement this programme, and this agency works in conjunction with the Department of Commerce in the interests of the small business.

Also, the use of advisory services for the small and medium sized firms is a growing practice in European countries.

The European Productivity Agency held a conference on the small firm in Munich at the end of May this year. There can be no question but that Europe is becoming alive to the importance of the small firm. Those of you who listened to Dr. Lillian Gilbreth yesterday will recall that she told us that she had found in her travels all over the world that it is small business which is vitally important to industry as a whole.

A mission went from the European Productivity Agency to America in March of this year to study this question of the small firm, and I would refer to a few points from their report. Dealing with the reasons for the failure of small businesses in America, they say that the main reason has been Unbalanced Management or lack of knowledge of good management. Most small business managers, they say, specialise in production, selling or accounting; very few are versed in all these. They also refer to co-operation between big and small businesses. One of the largest corporations in the United States, General Motors, have over 26,000 small suppliers, and General Motors have made it their policy and desire to guarantee these suppliers attractive margins of profit.

I should point out here a slight difference in interpretation. In America they talk about " small businesses," and I talk about " small firms." The factor of definition in America is on a dollar and cent basis. This difference of interpretation should be borne in mind in considering these extracts from the American report.

The third reference which I have selected is to the distribution of the products of small businesses. A remarkably large number of small manufacturers work solely as sub-contractors, or as a sub-contractor to a single big business. In one area which was studied, only 30% of the small firms produced for direct sale, and 70% were working on sub-contracts.

Those are extracts from the report issued by the European Productivity Agency, a body which is doing a remarkably good job in co-ordination and distribution of information apart from its other activities.

I should now like to quote one or two extracts from the semi-annual report of the United States Small Business Administration, which gives an American study on the same question. It is there stated that the Administration, which was set up in 1953, is intended to assist small businesses to gain access to adequate capital and credit. That is an important matter and deserves consideration at a time when we seem to be screwing down our credits in this country. Its second purpose is to see that small businesses obtain a fair share of Government orders, and its third to help them to obtain competent management, technical and production advice. That is one of the highlights of what is being done in America, the effort to obtain competent management. I gave you a figure of 56,000 odd small manufacturing firms in this country; the comparable figure in the United States is 311,000.

The problems of the small firms are referred to in this American report as follows: lack of facilities to engage in production research; reduced opportunity to obtain Government contracts; the high cost of carrying inventory (stocks); the pressure caused by the increase in mergers; imports jeopardising domestic markets; labour surplus in sections undergoing economic readjustment.

In dealing with future objectives for the small firm, the American report says it is expected that present trends in industry will intensify the problems of the small firm in the following ways. First, automation will place an even greater financial burden on the small firm for modern equipment, to keep up in the competitive race. Secondly, automation and atomic energy will increase the need for highly specialised personnel, which small businesses will have difficulty in attracting. Thirdly, the guaranteed annual wage, if applied to small firms, may impose a load which it is impossible for them to bear.

These extracts give some indication of the American point of view relative to small businesses.

3. The Basic Difference in Various Sized Firms

First of all, it is important to establish quite clearly that a firm, as it is called, is a collection of people and can only be as good and as keen as the people in it.

The next point to be established is that a firm is a group or groups of people with independent and, in most cases, specialised knowledge with their own individual group's purpose to follow.

The British people as individuals are very independent and, at all times, wish to express themselves in their own way. Also, the individual is very anxious to develop his own particular knowledge and technique and to make every possible progress not only for himself but for his family. I want to emphasise that. My critics think that I am biased towards the opposite sex, and so I am—to the extent that I believe that whatever people we are directly managing, we must look beyond them and realise that we are managing families. We have to realise that this country of ours is built up on the small spontaneous unit of the family, and these small businesses have the family very much in mind; so also (but more remotely) have the large businesses.

It will be seen on all hands how the individual in this country seeks for self-expression, and it will also be seen how keen the individual is to display his own particular talents. The founders and owners of the small firms, in the main, are men of this type. They have a specialised knowledge and keen desire to develop a specialised approach and consequently set up or develop a business for that purpose.

The incentive is very large indeed and the personal incentive is there without any question.

The name that goes over the works or on the letter-heading includes the whole family, and it is well known that Mr. Smith who starts his own firm is overjoyed when he is able to name his firm, " Smith and Son." But the son, if he is British, often wants to go off on his own and build up his own unit, and God bless him!

There is no doubt that people working in small firms have greater personal freedom and freedom to develop their specialised techniques. They choose work which is suitable for them and the head of the small firm starts off with work of his own choice and, therefore, the incentive commences right at the very beginning.

The Boss, " Gaffer " or whatever HE is called, is able to make personal contact with everyone working for him. There is no doubt in the minds of anyone working in a small firm, be it office boy, junior apprentice, the young lady who is typist, telephonist and reception clerk all in one, they all know what is meant when someone says, " HE is here! " These small groupings with keen and enthusiastic leaders have a joint purpose which they all understand and each person working in them is regarded by the Boss as an asset and not as a liability. These small firms, in any case, cannot afford any personnel liabilities and in this connection they set a very good example.

If we take the human body as the model against which our industrial problems can be related, with the small firm they are immediately aware of the importance of the "head," the "heart" and the "lungs," also the general " bone structure," and therefore quickly communicate and register their actions. The small firm like the human body is quicker to react than the large firm.

There is a more modern word describing this reference, but this subject has been separately dealt with at this Conference.

4. The Approach and Methods

In the first case, the small firm usually commences with small capital and operates at a very humble level. They have to, as it were, earn as they work and work long hours in order to establish continually that their income is likely to exceed their expenditure and, to this end, they rely a great deal on their specialised technique as appealing to the larger firm.

There is a considerable amount of work carried out between small firms as, if we trace many of the specialised commodities, it will be found that these have been handled by two, three or more small firms between each other. These specialised commodities do find their way on to aircraft, battleships, motor cars, electronic devices, etc.

It will be found that the relationship of these small groups is most important in their own development towards the larger firm, and in their own enthusiastic way they find means and methods of contact in order to satisfy the demand of the larger customer. They remind one of the story of the complicated part which could not be made by the large firm and consequently it was decided to " buy it out " and the order went to the small specialist firm.

This general reference to supplying the large firm is not just referring to the engineering side, but to the large customer such as main stores and warehouses, etc., who very frequently will purchase from a small firm a fair percentage of his annual output. Whether it be mouse-traps or tin-tacks, fish-hooks or bent wire, it will be found usually that the small firm is relating his activity to the large demand, thus permitting him to continue in comparatively large volume in his specialised line.

The small firm does not usually wish to be tied but wants freedom to develop specialised knowledge and techniques, thus permitting an intense and close study to be made of a particular type of product and method of production, which usually results in a product which is not only to a good standard of quality, but at a competitive price.

The small firm can and does apply modern thinking and, in many cases, modern methods, but all of these applications are based on sound reasoning and hard business sense, and not just put into operation because it is a good idea or because it is an instruction from Head Office; " HE " is the Head Office.

The story of the " Tin Tack " or the " Bent Wire " are stories of the small firm. The largest makers in this country of the " Tin Tack " employ 45 workers, they sell to over a hundred merchants and the product, as is well known, is used everywhere.

There are automatic machines making nothing else but BENT WIRE PARTS, from paper clips to wire toys, from essential clips for aircraft to bent pins for jewellery. In fact, for every trade and almost every use there is a bent wire and one good example of a large producer is a small firm employing 35 people.

Another story is of a small firm now employing just over 30 people. This firm was started with a capital of only £300 in 1948, and is now turning out equipment to the value of over £100,000 per year. The equipment is for drying air and gases and certain organic liquids.

This small firm builds to the construction requirements and material specifications used in American and British oil refinery practices, which are some of the highest standards in the world.

All the gas drying equipment connected to the atomic power reactors in the world's first nuclear power station at Calder Hall was made by this small firm, and further, no less than 38% of their products go to atomic energy (power and chemical) establishments.

Development of this equipment has been of the fully automatic type and used both at home and for export.

One other story of a similar type concerns a small firm employing just over 50 people making, by the latest automatic methods, no less than 50,000 synthetic sapphire bearings per week.

Originally, these bearings were made by hand, but are now produced by automatic machinery to an accuracy which is easily competing with Switzerland, who used to be the main source of supply. Here again, these precision bearings are to be found on all types of precision instruments, ships' compasses and many other precision applications.

My search for information from the small firms has given me a complete thrill, and I quote only four examples above, out of the many I investigated.

5. The Relationship Between Trade Unions and National Agreements, the Factory Acts and General Welfare

First of all it must be clearly established, and I believe it to be substantially true, that in the small firm there is an overall sense of " belonging " to that firm and a sense that each individual in the firm is a very definite part of it. Individuals in the firm are usually aware of their purpose whether they are workpeople or staff and they know that in the main they can have an easy contact with the " Boss."

Frequently, the working conditions and welfare standards do not line up in many ways with the best standards in the larger firm. Nevertheless, there is a clear knowledge as to what is required and there is a facility to express themselves as individuals in order to know exactly where they stand.

It will be found in the larger firm, where first-class canteen facilities are provided, that the individual in many cases prefers to sit at his place of work and have a home-prepared snack, and frequently one finds in the smaller firm a tea-making point or small canteen which is run by themselves and is often more enthusiastically used, although not to any high standards. It belongs to them: it is theirs.

It is important, therefore, to study this background and the facility to avoid feelings of frustration in studying the attitude towards the Trade Unions and national agreements, etc., as on the whole it is very rare that there has to be any serious outside influence for negotiation brought to bear by the Trade Union on the small firm. Problems are usually settled on the spot by the Boss, who is the Boss in every sense of the word. Even if there is a point of dispute which brings in the Trade Union or the Factory Inspector, the matter is usually very quickly settled.

6. What the Small and Large Firms can Learn from each Other

Much can be learned by the large firm from the small firm because if the large firm can, so far as is possible, emulate the smaller grouping of people under a recognised leader, whether he be Foreman, Superintendent or Manager, with power to run his section as he wishes, this can lead to a better understanding of that group's purpose.

Unfortunately, in a large firm, however much responsibility is placed on the junior supervisor, the overall policy of a large Company has to have some influence on the small group's activity and, on major issues, the final decision of policy has to be made on a reference back.

With large organisations where there is a somewhat remote control, giving opportunity for a feeling of frustration, this, if not handled quickly and by the local departmental " Boss," can lead to major domestic troubles.

It is evident, however, that the best tendency in the large firm is to allocate an area to a manager or superintendent and not tie him too tightly by standard procedures as laid down by some remote central organisation. This does not mean that it is impossible to manage a large firm satisfactorily, but the indications are that the problem is more difficult and requires continual contact with the small groups by the people interested in personnel.

The small firm can also have greater flexibility in dealing with a problem or with a new technique in that they have their own freedom to probe and find a solution quickly without having to " refer back." Few, if any, " internal memos"!'!

The large firm, on the other hand, usually having more capital, can invest in modern plant and machinery and, in this respect, can help the smaller firm to develop towards new techniques. Our views in this connection are coinciding with those of the United States.

The large firm, as a rule, has to spend considerable time in the development of various processes whereas the small firm is much more flexible and is more able to take, as it were, short cuts in order to achieve a particular objective.

Considerable opportunity is available for the large or parent firms to give more interest to the small firms who supply them and thus to help them to have a closer understanding of the requirements.

The establishment of quality standards is an example where this help can be given.

Early consultation between the purchasing firm and the supplying firm is necessary, be they large or small. Give the fullest explanation of what is wanted and why it is wanted, as, by such contact, mutual trust and understanding should be built up. Confidence is just as important between large and small

firms as it is between management and men, and if the firm concerned knows the purpose of the part which they are making, this in any case will go a long way towards meeting the required quality and cost standards.

7. The Main Features Which Govern Both

Many of the points of comparison which have been made so far deal with the inside of the factory and its internal management, techniques and objectives, but there are over-riding influences which affect all factories, be they large or small.

The basic costs of electricity, coal, fuel, etc., the cost of raw materials and the cost of transport—we see this morning that the cost of certain of these commodities is again going up.

The small firm, like the large firm, has to fall in line with these outside items of cost with little or no opportunity to do other than accept the situation as they find it. Transport can represent one of the major problems for the small firms, as goods which they make have to be transported many times from firm to firm and this has to be undertaken usually by road under conditions of deplorable congestion. If, for example, certain areas in the Midlands were viewed from above during the industrial day, they would appear much like an ant-hill, with these " little ants " (lorries and trucks) running backwards and forwards, and this continual movement could be as confusing to the onlooker as ants on an ant-hill.

What they are in fact doing is carrying their goods from small factory to small factory and from small factory to large factory, but the congestion causes this traffic to slow down or even stop, and in this connection the ant has an advantage, as one ant can climb over the top of another ant and thus get on with the job. Our industrial congestion with trucks and lorries does not give this relief.

The small firm, in line with the large firm, is also tied to Government legislation, filling up forms, permits, Pay As You Earn, taxation, wage structures, etc., and all these extraneous items which have " crept up," as it were, behind the small firm over the years, placing a burden on the small firm which calls for additional staff and additional costs.

Industry as a whole, be it large or small, is " trammelled " by much of the present day over-riding national legislation and taxation.

8. The Human Factors, Including Training and Education of Young People.

Certain aspects of the human factors in the small firm have already been dealt with but, unfortunately, there is more remoteness in the large firm and the delegation of contact has to be passed on, apart from the direct line of production supervision, also through the Personnel Manager's department.

The large firm, however, can help the small firm, particularly in connection with the education and training of young people and the future will stimulate action in this direction in view of the increasing demand for scientists and technologists, apart from craftsmen.

Small firms have not the same facility as the large firm in this connection, but by association it is felt that the large firm can help considerably.

I believe that there is a great work to be done in this country in extending the opportunities for training of our young people, be they boys or girls, and it should not be assumed that only the large firms can undertake this training in conjunction with the technical colleges.

I think that all our young people, having left school, should be subjected to further training and study, and I feel that there is an opportunity, by consultation with the Ministry of Education, the larger firms and with the smaller firms, and the technical colleges, for a widening of our training activity in industry, particularly in helping the junior staffs and workpeople of the small firm. I would like to enlarge on this subject, but time will not permit.

9. General Summary Relative to the Conference Theme

Now, how can this subject be best summarised, bearing in mind that industry in this country is like the firmament of Heaven, a vast inter-related collection of " suns, planets and stars? " Not so many, perhaps, in total number, but just as variable one to the other and as complicated.

Be it *bent wire* or *calculations*, both can be produced automatically provided the volume justifies the installation or technique, and therefore automatic production is not necessarily the prerogative of the large firm.

Sensible rationalisation of design gives volume and volume permits of automatic production which, in turn, improves quality and quantity, reduces costs and above all allows a good standard of wages and living.

The small firm by virtue of its specialised product which is supplied to the whole of the country or to the whole of an industry has a volume which is more likely to justify automatic production, both on batch or flow application.

In studying the word " CHANGE," how important it is to keep our products and methods up to date, as now, and more than ever in the future, must we rely on our export of finished goods, as we have very little exportable raw material on this island other than coal, which we cannot bring to the surface in sufficient quantities. This being so, at all times must we be competitive not only with our designs, but with our production methods.

It is usually the small firm which also provides our " first offs " and experimental parts, also the small firm can be more flexible and more quickly move over to a new product as in many cases the mental approach, as well as the plant, can be adapted more quickly with much more local concentration than can be given by a large firm.

The small firm is controlled chiefly by common sense and freedom to move into a new field of production and to become associated with a new technique by their own *enthusiasm* and not by *instruction.*

(*concluded on page* 658)

"Automatic Production – change and control"

CONFERENCE, HARROGATE, 30th June - 3rd July, 1957

Continuing the publication in the Journal of Papers presented at the Conference, this issue contains the following :-

SECOND PLENARY SESSION

"What About the Small Firm?" by E. W. Hancock, M.B.E., M.I.Mech.E., Hon.M.I.Prod.E., F.I.I.A., F.R.S.A.

DISCUSSION GROUP C1

"Machine Tools of the Future" by Denis Player, M.I.Prod.E., F.Inst.D., Mem.A.S.T.E. and W. K. Temple, A.M.I.Mech.E., A.M.I.Prod.E.

DISCUSSION GROUP C2

"Transfer Pressing" by Gordon M. Sommer and Robert H. Barlow.

DISCUSSION GROUP C3

"The Application of Unit Heads and Special Machines as an Aid to Batch Production" by G. H. Asbridge.

DISCUSSION GROUP C1

MACHINE TOOLS OF THE FUTURE

by DENIS PLAYER, M.I.Prod.E., F.Inst.D., Mem.A.S.T.E.

and

W. K. TEMPLE, A.M.I.Mech.E., A.M.I.Prod.E.

Mr. Player, who is a Director of the Newall Group of Companies, was educated at Worcester Academy, Massachusetts, U.S.A. He served his engineering apprenticeship partly with the Federal Products Corporation of the U.S.A., and partly with the Newall Engineering Co. Ltd., London. During the early period of the last War he served with the Royal Artillery, afterwards joining Optical Measuring Tools, Ltd., of Slough, one of the Newall subsidiaries, as Managing Director, which appointment he held until 1945. *He then returned to the Newall Engineering Co. Ltd., Peterborough, to establish a selling organisation (Newall Group Sales Ltd.) to handle the products of the Newall Group of Companies.*

Mr. Temple, who is Chief Engineer of the Newall Engineering Co. Ltd., was educated at Kinmel School and at Hull Technical College, serving an engineering apprenticeship with Messrs. R. Sizer Ltd., Hull, and afterwards as a designer with the same company. The first part of his War service was with the Royal Armoured Corps, and later he was appointed instructor at the Military College of Science (School of Tank Technology) which included a period of attachment to the American Army during investigations into enemy armoured vehicle manufacture. He joined the Newall Engineering Co. Ltd. as General Manager in 1946.

TO cover completely the subject of machine tools in automatic production would be too ambitious in a Paper such as this one; nor is it likely that any one person could do justice to such a wide field. On the one hand, we have vast transfer machines ; the productive elements of which these are composed are not too dissimilar from conventional machines as we know them, although their linking together so that they work in close harmony is a matter requiring much skill and ingenuity by mechanical, electrical, hydraulic and pneumatic engineers, as well as by those versed in cybernetics. Such machines form the core of the automatic factory, whose main function may be presumed to be that of producing large quantities of high quality consumer goods at low cost.

On the other hand, we have machine tools which in some ways are small automatic factories in themselves; generally these are concerned with the manufacture of complex components in smaller quantities, and again the emphasis is on high quality and low cost. It is with certain machines in this category that we shall be concerned in what follows.

We are all aware of the economic stimuli which

have caused the trend of transfer of skill to a place more remote from the cutting tool itself, and of the division of skill whereby the machine takes a larger share of the responsibility for accuracy and speed; so these will not be laboured here. A further spur which has forced us along the same road is the fact that man, in spite of frequently justified criticisms of the reliability of the machine, is still the most unreliable factor of all, so that it is natural to try to remove him as far away as possible from direct contact with the product, and put him somewhere where his output can be checked and rechecked before it causes a wheel to turn.

The greatest stimulus

Added to all this we have perhaps the greatest stimulus of all—man's innate curiosity; and in recent years this has certainly led to rapid development in the fields of electronics and servo system design. The latter has been credited with making the automatic production line a possibility; but in fact this is hardly the case, as such machines rely to a great extent on cams, levers, limit switches and so forth which are set up to suit the particular job in hand and then operated on a predetermined time cycle. The point is that the movements between machining stages can be quite crude, and the accurate locations and precisely timed movements are needed only over short distances and with relatively small effort within the particular stage. Under these circumstances, the simple mechanisms mentioned above give a faster action for the same accuracy than could be achieved with servo drive. To take an extreme example, it would be stupid to replace the cams operating the valves of a car engine by servos. Where these advances have made their impact, however, is in some of those machines with which we propose to deal here—machines in which precise control is required continuously, of which very high accuracies are demanded, and which have to perform functions so complex and so variable that a mechanical solution to the problem by the design of cams and linkages would be imposible. It is in this field that the electrical engineer has to a great extent outstripped the mechanical engineer, and it is the effect that this must have on machine tool design, and on the attitude of the machine tool user, that should provide us with much to discuss.

To look far ahead in an era of such rapid technical advancement as that in which we live is impossible, and to be dogmatic about what changes will occur even in the near future is equally dangerous. But it is indisputable that right now some fundamental changes in the mechanical design of certain machine tools will have to be made; furthermore, the user may have to change his attitude towards these new tools if they are to be exploited to maximum advantage.

Let us say then that our aim is to develop to the full the high accuracies attainable by modern methods, electrical or of other form, and at the same time transfer control from the operator to the machine itself and to the planning engineer. In a discussion about high precision machine tools the example that most readily springs to mind, and with which we are all familiar, is the jig boring machine, perhaps better described as the co-ordinate setting machine; accordingly we shall take this as our main theme and examine the effects of applying automatic control to it, both from the points of view of the eventual user and the machine tool builder.

Automatic co-ordinate positioning

When considering automatic positioning of a machine there is one basic essential fact that whatever tolerance of setting is chosen, the machine must position its table within that tolerance, not 99 times out of 100, nor even 999 times out of 1,000, but *every* time. This was the target which the Newall Engineering Co. Ltd. set for themselves and the tolerance, in accordance with the accuracy expected of a jig borer, was .0001". Such a fractional dimension is easily talked about, but it is not always appreciated how very small it is ; 1/10,000th of the length of R.M.S. " Queen Mary " is only a little over 1".

For many years we experimented with rapid setting mechanical measuring systems, and one of our patents is at present being used under licence by manufacturers in both Europe and the U.S.A. But it became increasingly obvious that such systems could not be relied upon to repeat to the required degree of accuracy, which essentially must be less than the final target of .0001" if one is to have any latitude for error in the rest of the machine. It was apparent also that conventional slideways and driving mechanisms would not permit of machine tables repeating their positions to this same limit *every* time under automatic control, particularly in face of variations in lubrication conditions, work loading and temperature.

Accordingly we were led to explore systems of measurement other than mechanical and in the field of electronic engineering we found the answer. In fact, we were presented with potential accuracies in excess of those we were expecting ; but it was up to us to exploit them to the full by careful attention to mechanical design. The measuring and control system chosen was that developed by Messrs. B.T.H. Ltd., of Rugby, and the machine which embraces this system has been given the descriptive trade name of " Spacematic " (see Fig. 1). It is not intended here to go into a detailed description of the B.T.H. system, as those attending this Conference will no doubt be familiar with its principles, which have been widely published in technical journals; for the benefit of those who may wish to refresh their memories, however, a brief explanation of the system is given in Appendix A to this Paper. For the moment, suffice it to say that the required co-ordinate dimensions are dialled into a control desk (Fig. 2), either manually or by means of punched cards, and upon being instructed the machine table will proceed to the preselected position automatically.

From the very beginning, and in the closest co-operation with B.T.H. engineers, the machine was

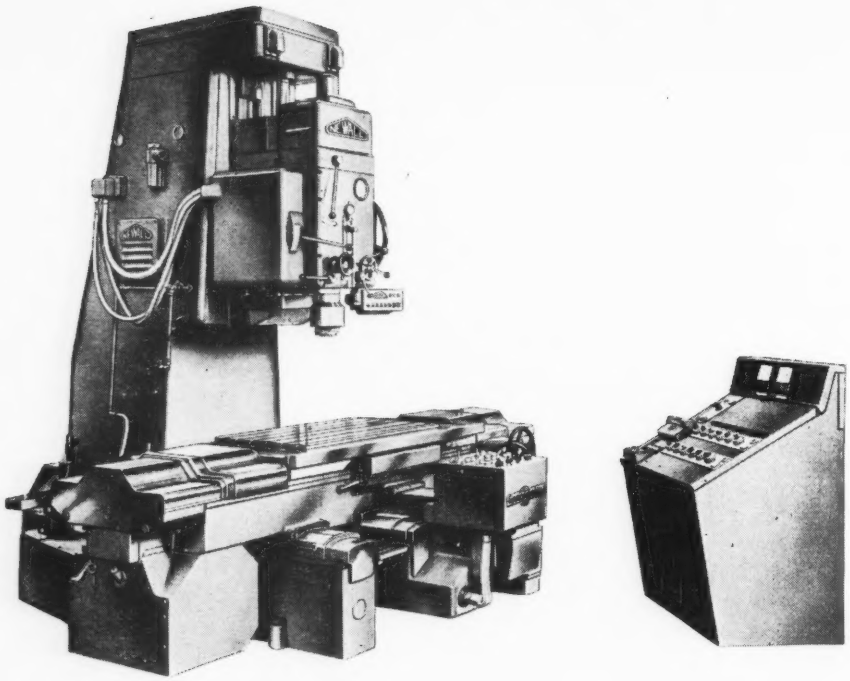


Fig. 1. The Newall " Spacematic " automatic co-ordinate setting jig boring and milling machine.

Fig. 2. The B.T.H. control desk, showing hand setting dials and automatic card reader.

designed to dovetail exactly with the requirements, facilities and potential performance of this measuring and control system, and we achieved results which were if anything beyond expectations. In the first place, the repeatability of slide setting was found to be in the region of fifteen millionths of an inch, and appeared to be quite independent of load or other normal variables: in the second place, the facility with which the master scale system could be adjusted enabled the absolute accuracy of spacing over the working area of the table to be calibrated within our own limits of error determination using N.P.L. length standards, a figure in the neighbourhood of fifty millionths of an inch over the lengths involved. This, of course, was all to the good, for just as when checking a component one chooses an instrument possessing a higher resolution than the tolerance to be measured, so in a machine tool it is necessary to have a measuring system of inherently better accuracy than the guaranteed final setting accuracy.

Firstly, let us pin-point a few of the factors from the electrical point of view which have contributed towards, indeed, which have made possible, these setting accuracies:

1. The direct electric current motors which drive the traverse screws are under control of an error signal fed back fom the electro-magnetic measuring head during the last stages of the positioning cycle. So long as an error in the relative positions of the detector head and measuring bar exists, the former will produce a voltage proportional to this error which, after amplification, is made to drive the traverse motor. The speed of the traverse motor will be proportional to this amplified error voltage, so that as this is reduced so also is the motor speed. Accordingly the final approach is under tight control and at a speed gradually decaying to zero as coincidence is reached. Furthermore, irrespective of the distance to be moved, or of the direction in which this movement is to take place, the slide is first driven to a "false zero" which is .02" away from and always on the same side of the final position. Hence the final approach is always in the same direction and over the same distance, so that conditions are identical at every setting.

2. The sensitivity of the detector head is such that a displacement from coincidence amounting only to fifteen millionths of an inch is sufficient to drive the traverse motors, so that only when the residual positioning error is within this region is the cycle completed and the table automatically clamped.

3. As there is no physical contact between the detector head and the measuring bar, no mechanical wear takes place; hence there is no deterioration of accuracy as happens, for example, when a power lead screw is used for measurement. This is of special importance in the case of automatically controlled machines, as the positioning cycle will occur far more frequently than with hand setting machines.

4. The measuring bar itself is manufactured from a highly stable corrosion-resistant steel of rigid section having a coefficient of linear expansion the same as that of cast iron; as such it can be handled quite safely and is unaffected by changes in humidity. Its "magnetic centres", which are at 1" intervals throughout its length and can be compared with the main divisions on an optical scale, for example, can be moved relative to each other by very small distances by means of screw-driver adjustments to small slugs of magnetic material (see Fig. 18, Appendix A). Thus it is possible, after calibration of the bar in the finished machine tool, to reduce spacing errors to a negligible amount.

5. The accuracy of the system is independent of fluctuations of the voltage or frequency of the electric supply.

Turning now to the mechanical design, the majority of the problems of automatic control belong purely to this sphere and it is on this account that close liaison between the machine tool and the control system designers is essential. Automatic control frequently makes demands on the mechanical system beyond those normally experienced in conventional machine tool design practice. Consequently, machines designed in accordance with established practice may give disappointing results when automatic control is applied.

Although the control engineer can and does devise ways and means of alleviating some of the worst resulting effects, he can never eliminate them entirely and, very often, devices which relieve one problem may accentuate another, or introduce some new problem of their own. It is, therefore, important that the machine tool designer should understand thoroughly what the automatic control will attempt to make his machine do.

There are two most important mechanical characteristics required of machines having automatic control:

1. Stiffness of the drive from the feed motor to the final output motion. A "springy" drive introduces a time lag between motion of the motor and corresponding motion of the machine.

2. "Stick-slip" friction characteristics which, in combination with a springy drive, cause the output motion at low speeds to break down into a series of jumps, although the motor may be rotating smoothly.

Dealing with stiffness, it is apparent that the effects of this can be alleviated considerably by reducing the amount of work the drive has to do. This can be achieved by reducing frictional forces

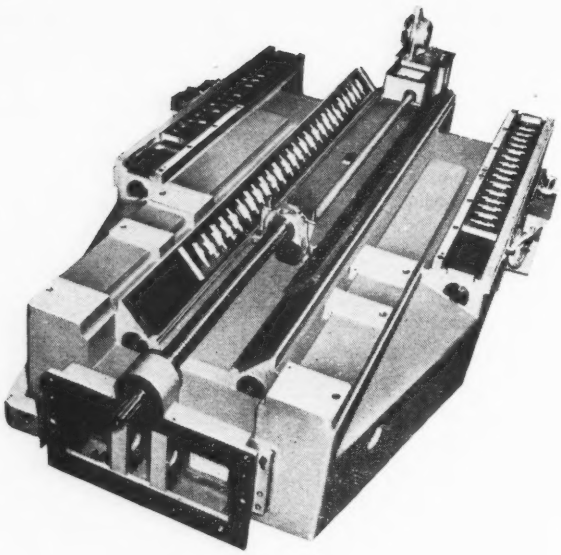


Fig. 3. The " Spacematic " base with slideway rollers in position, before fitting cross-slide.

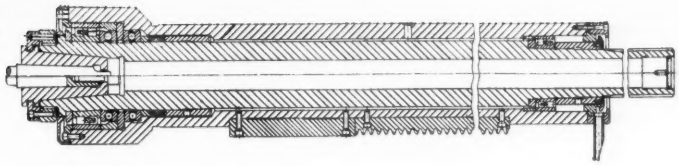
in two places of primary importance. Assuming that the slide is driven by means of a screw and nut, the latter can be made the ball-recirculating type which, suitably designed, has a very high efficiency. But this in itself, although helpful, is tackling the problem too far back in the train ; what is required is a substantial reduction in the effort that the screw has to impart to the table. Accordingly from the earliest days it became apparent that to achieve our goal, research and experiment into slideway friction was of paramount importance.

Firstly, it was necessary to reduce the dynamic coefficient of friction so as to keep power requirements within reasonable bounds and at the same time assist the solving of the problem of drive stiffness ; secondly, investigations would have to be carried out into the change of dynamic friction concurrent with changes in slide velocity (particularly at the extremely low speeds employed during final setting) and with variations in work loading ; and thirdly, the machine tool builder's *bête noire*, " stick-slip " had to be overcome. Over a period of years many tests were carried out, in which the Production Engineering Research Association gave most valuable assistance, with a view to overcoming these difficulties.

Finally, after consultations with the S.K.F. Ball Bearing Co. Ltd., both in England and in Sweden, it was decided to adopt a roller slideway design (Fig. 3). Eventually a satisfactory method of spacing and guiding the rollers was evolved, together with a new technique for manufacturing the slideways themselves, not only to the necessary degree of accuracy for straightness and twist, but also so as to ensure conformity between the two slide surfaces mating through the medium of the rollers. The manufacture of the rollers themselves presented little difficulty on account of past experience of similar work, and these are held to limits of size and geometrical truth of 20 millionths of an inch, final accuracy being achieved by selective assembly. In this design the ultimate certainly has not been reached, but even at this stage we can say that " stick-slip " has been eliminated, that the frictional force is almost indepen-

Fig. 4. Hardened and ground cross traverse lead screw with recirculating-ball nut.

Fig. 5. **Sectional arrangement through "Spacematic" main spindle.**



dent of the load on the machine table, and that this force is so small as to allow a total weight approaching four tons to be pushed along easily with one hand.

Here then would seem to be one of the major factors in machine design of the future. The particular solution we have adopted is, of course, neither novel nor is it the only one. In fact, slides of this type have been in use on certain machines for years, but it does seem that they will be utilised more widely in the future. A secondary design problem associated with roller slides is their protection from the ingress of dust and swarf, and this must be 100% efficient ; the difficulty of the task is aggravated by the fact that it is impracticable to wipe or scrape the one member prior to the approach of the other.

The next step was to ensure that friction was kept to a minimum and stick-slip eradicated all the way back to the motor shaft. Accordingly a recirculating-ball type nut was used in conjunction with a hardened and ground lead screw, and all rotating members mounted in anti-friction bearings.

In order to ensure adequate stiffness throughout the drive, the lead screw itself was made $2\frac{1}{2}$" diameter (Fig. 4). When it is considered that the torque required at this screw, which has a pitch of $\frac{1}{2}$", is only about nine-pounds-feet to move a mass of nearly four tons against a simulated tool thrust of 1,000 lb., it can be said that such a screw is truly massive. It is of equal importance, of course, that the thrust and journal bearings which locate the screw, together with the brackets or other components in which these bearings and the nut are housed, are of a stiffness of at least a comparable order : in fact, the bearings used were of the same design and ultra-precision quality as those used in the main machine spindle. For the same reason the lower speed drive gears must be of adequate pitch, face width and of good tooth profile, in order to reduce tooth deflections to negligible quantities.

The expense factor

Perhaps at this stage it is worth pointing out that these features are not incorporated without the expenditure of money, and it is necessary that the user should appreciate that automatically controlled machine tools themselves, apart from the not inconsiderable cost of replacing some proportion of human skill with electrical equipment, are by their content bound to be considerably more expensive. Furthermore, the setting accuracies achieved by taking such care with the mechanical side show this to be fully justified, and emphasise the fact that it is impossible to turn a conventional machine tool designed for one purpose into a high precision co-ordinate setting or continuously controlled machine by simply adding to it electrical gadgetry, however efficient and precise the latter may be in itself. The machine tool designer has reached a " Halt — Major Road Ahead " sign ; it is of no use continuing on along the minor road, for the turning must be taken.

What has been said so far is not particularly original, nor is that which still has to be said ; these factors have been known for some time, but have been pushed somewhat to the backs of our minds by startling and rapid developments in the electrical field.

We will turn now to other aspects of machine design which, although they have no direct bearing on automatic co-ordinate setting as such, are of great importance to the ultimate accuracy of the component produced by the machine.

The main spindle

From the main machine spindle (see Fig. 5) and its drive we require the following :-

1. Maximum rigidity of the spindle itself, by choice of suitable diameter and bearing spacings.
2. Freedom from both radial and axial play, and minimum bearing deflection with tool load — achieved by good bearing design and adequate pre-loading.
3. Concentric running of the spindle bore to a high degree of accuracy so that precise fixed-size cutting tools, such as reamers, may cut holes which are round, parallel, to size, and in their proper places. This requires not only rolling bearings of the highest possible precision, but also that the spindle, its quill or housing, and all components connected with the mounting of the bearings be manufactured to the same degree of dimensional and geometrical accuracy.
4. Adequate power and high maximum speeds to take full advantage of modern cutting tools.
5. Freedom from vibration so as to ensure high surface finishes.
6. Minimum temperature rise.

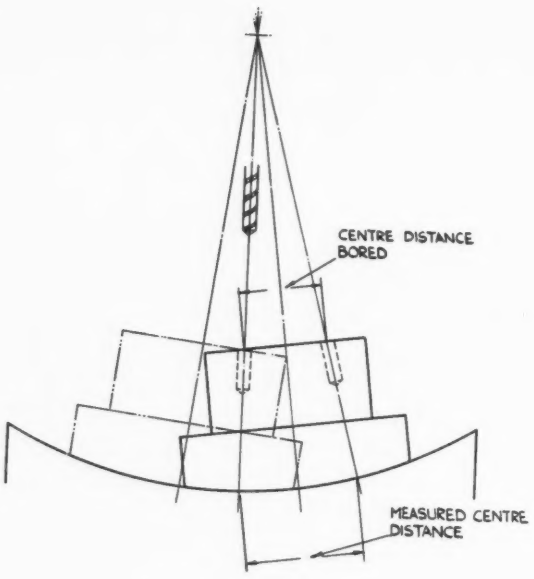
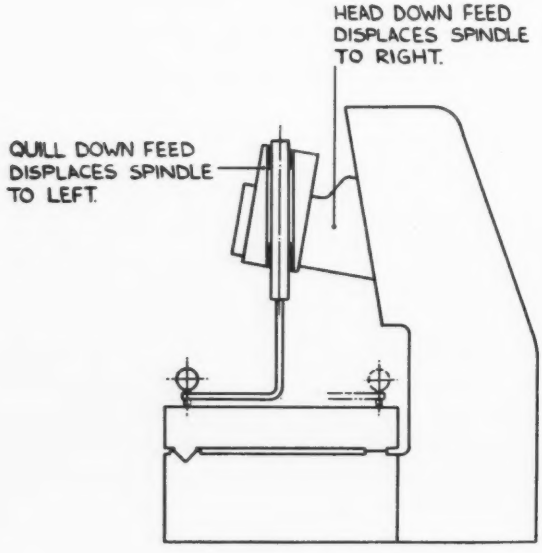


Fig. 6. Diagram illustrating the effect upon spacing accuracy of slideway curvature.

Fig. 7. Diagram showing that a correct trammel check can permit gross errors of quill and column alignments.



The last item is of particular importance in machines having control of three co-ordinates, as any growth of the tool towards the work due to excessive heat will affect accuracy. Careful selection of bearing types which from the start have been manufactured to ultra-precision limits (not just the best bearings selected from standard production) ; meticulous care in the preparation of seatings and housings ; choice of mounting methods ; absolute cleanliness ; proper lubrication — these are the essentials for low temperature operation. By proper attention to these details we find it possible to run pre-loaded spindles having bearings of $2\frac{1}{2}$" diameter bore continuously day and night at 2,500 r.p.m. with a temperature rise in the neighbourhood of 5°C. ; we use oil-mist lubrication at a few pounds per square inch pressure, which has the added advantage of preventing the ingress of dust into the spindle bearings.

Machine alignments

To go into much detail here would be tedious, but it should be appreciated at once that merely to fit an accurate measuring system to a machine table is not to ensure accurate spacings on the workpiece. If we speak of positioning to ten thousandths parts of inches, then we must know firstly that the slides will progress in a straight line when moving, and not waltz from side to side due to inadequate guiding ; furthermore, the two co-ordinate motions must be truly at right angles to one another within extremely close limits, otherwise four holes bored nominally at the corners of a square will in fact be at the corners of a parallelogram and the diagonal centre distances will differ from each other accordingly.

Apart from the errors in hole positions which obviously must result from bent or wavy slides, or from co-ordinates which are out of square with one another, there is a further effect which perhaps is not so obvious at first sight. Abbé laid down that for highest measuring accuracy the plane of the master scale should be as nearly coincident as possible with the plane of measurement. In a machine tool this is obviously impossible ; firstly, the plane of the work machined surface depends on the height of the work; secondly, the scale itself must be protected — usually by putting it below the machine table surface. In fact, the scale usually has to be mounted underneath the table casting as, if we apply the Abbé principle in the other plane, it is desirable that the master scale should be centrally disposed in the width of the table slides. A novel design feature of the "Spacematic" has enabled this to be achieved, so that in spite of deep-sectioned table and cross-slide members the scales are not only centrally disposed to their respective slides, and reasonably close to the table surface, but are both nearly in the same plane as each other.

Consideration will show that if a sliding member, instead of moving along a straight line, is moving in an arc of a circle of very large radius, the centre of which we will imagine as being above the machine, then an *actual* movement of, say, 10" measured at the

scale *below* the table top will appear as a smaller movement on the work surface which is *above* the table top (see Fig. 6) ; in the limit, if the work surface were situated at the centre of this large imaginary circle, then two holes bored apparently 10″ apart would in fact be coincident on the surface of the work and diverging slightly as they went deeper. Now this may sound rather theoretical and of no practical significance, but a few figures will prove that this is not the case.

Let us imagine that our master scale is in the same plane as the slideways, and that the table surface is 6″ above this ; let the workpiece be such that its working plane is 12″ above the table. Let us say that the table is 24″ long, and that the slides are bowed to the extent of only .0005″ over this length, Under these conditions the spacing error on the work surface would amount to .003″ in the whole 24″ ; i.e., .000125″ per inch — and this perhaps from a measuring system intrinsically accurate to the proverbial "split tenth". So let us realise that even such a small error as .0005″ in 24″, that is .00025″ per foot, can turn a precision jig borer into a drilling machine. The matter is aggravated further by the fact that a typical jig boring machine may have a maximum gap between table and spindle nose of 30″ or more ; at one moment it is using every inch of this capacity, and at the next it may be boring a piece of gauge plate sitting on 1″ thick parallels.

From the above it will be apparent that the same kind of error can be introduced in the other plane if the guideways allow the table to travel in an arc around some distant vertical axis. This is why we like to place the master scale along the centre line of the table, for although it does not mitigate the total error that can arise from curvature, at least it halves the possible error between scale and job.

So again it becomes necessary to emphasise that a machine will not necessarily produce precise work just because its measuring system is precise, and that very slight slideway curvature can soon put a machine right out of expected limits. Once again the final result is added cost : castings must be aged, either artificially or naturally ; they must be machined in a number of stages at well-separated time intervals ; and, finally, they must be scraped with infinite care and extreme skill to tolerances which demand exceptional and lengthy measuring techniques, such as auto-collimation. Even having achieved such accuracy initially, however, spacing errors are bound to creep in as time goes on due to slight wear of the slides, which is rarely uniform ; but many years should elapse before this has a sensible effect on normal work : an added attraction for the roller slideway is that it is doubtful whether significant wear will occur even after many years of service.

Another factor which for similar reasons to the above has a direct bearing on spacing accuracy, is the rigidity of table, cross-slide and bed castings ; the component dead weight on a jig borer table may be a few ounces one minute and over one ton the next and, if the resulting deflections of the machine elements are allowed to become significant, temporary slideway curvature with its attendant errors will ensue.

Similarly, the spindle and spindle head alignments are of vital importance in producing accurate work. For years the trammel check has been slavishly adopted as a criterion of precision. In this, a dial indicator mounted on an arm attached to the spindle is caused to sweep the surface of the machine table and show only a small variation. This test is of importance certainly, but only when it is related to other and more significant tests. The trammel test shows that the rotational axis of the spindle is vertical to the table surface, but it does not show whether the axis of the quill in which the spindle is mounted is also normal to the table ; if it is not, then movement of the quill up and down will cause the tool point to move sideways. Again, if the column ways on which the spindle head slides, are inclined from the vertical, this will have the same result. And, of course, both faults may occur together, and in both planes, but still the trammel check may be perfect (see Fig. 7). When machining has to be done on different levels of a workpiece, or when holes are deep, such alignments as these are of great importance ; in extreme cases even a different length of cutting tool can cause spacing errors from these causes. To show the meticulous care necessary in the manufacture of jig borer quills and of the housings in which they are slidably mounted, both of these components are collimated for straightness on opposite sides of two right-angular planes, and are rejected if the error exceeds 20 millionths of an inch in their respective total lengths ; tolerances on roundness and parallelism are 20 and 30 millionths of an inch respectively (see Fig. 8).

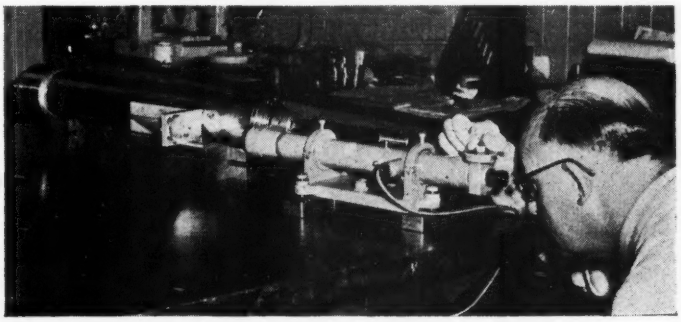


Fig. 8. An inspector using an auto-collimator to check a jig boring machine quill for straightness ; quill housings are checked in a similar manner.

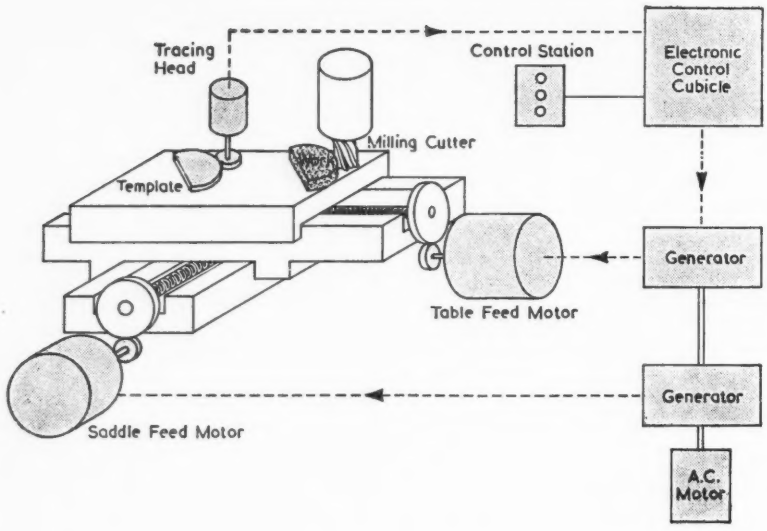


Fig. 9. Schematic arrangement of tracer control of two dimensions for a vertical milling machine.

Profile generation by copying

Firstly, under this heading let us consider tracer-controlled machines, in which the component is produced by automatic copying of a master component, former or templet. This is a well-established art with which we are all familiar, but once again the time has come for a review of the mechanics of machines to which such control systems are fitted, as the electronic engineer has broken into this field also with tracing heads of very high sensitivity. By using the appropriate copying head and control gear, control may be applied to one, two or three dimensions ; as we have been dealing with machines having automatic control to two right-angular co-ordinates, we will continue with this theme by discussing two-dimensional tracing only, although the conclusions reached will be equally applicable to the other systems.

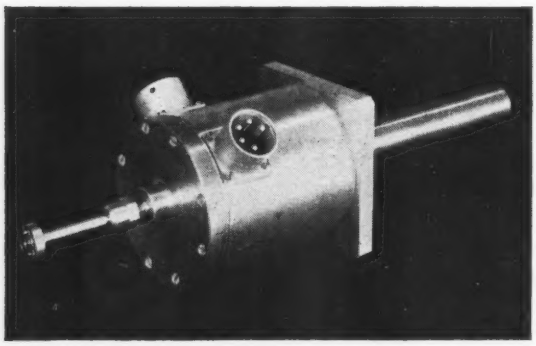


Fig. 10. The B.T.H. two-dimensional tracer head with stylus fitted.

The B.T.H. two-dimensional tracer control system provides simultaneous control of two feed motions normally perpendicular to each other (see Fig. 9). Such systems are not limited in direction of cut and are usually arranged to maintain a constant feed rate over the work, irrespective of direction of movement.

A tracing head (Fig. 10) has two electro-magnetic circuits at right-angles to each other, each giving an electrical signal proportional to the amplitude of stylus deflection measured parallel to its own pole pieces. Referring to Fig. 11, the stylus is shown in contact with a templet and deflected at an angle θ to the x –axis. The signal obtained from the x –axis of the head has a magnitude of $Kd \sin\theta$, where K is the sensitivity in volts per inch, and the stylus deflection is d inches. Similarly the y –axis gives an output of $Kd \cos\theta$. These are alternating current signals and may be of any chosen phase, depending only on the phasing of the excitation applied to the head. Hence, if the x – and the y –axis coils are excited in phase quadrature, the resultant signals will be as shown in Fig. 12. If the two signals are now simply added together, a single resultant signal of magnitude Kd and phase angle θ, will be obtained.

This signal thus represents, by its magnitude and phase angle, the amplitude and direction of stylus deflection. After certain corrections and modifications have been applied, this signal is then passed to phase-conscious rectifier circuits which resolve it into sine and cosine components, delivered as direct current voltages. These become the reference signals for the speed regulators controlling the two feed motions, and cause them to run at proportional speeds and in directions corresponding to the polarity of the direct current voltages.

The two feed motions then combine to give a

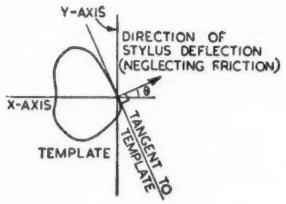


Fig. 11. Diagram illustrating two-dimensional stylus deflected by model.

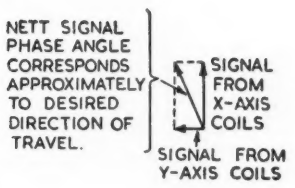


Fig. 12. B.T.H. two-dimensional control — signal phase angle.

resultant feed which is tangential to the templet and is of constant, but adjustable, magnitude.

The operator is usually provided with a "steering" control which enables him to steer the tool in any desired direction when the tracing head stylus is free of the templet. On meeting the templet, the system automatically changes over to stylus control and will follow round the templet profile in a direction determined by a selector switch, so as to permit of conventional or climb milling methods, and at a speed set by an infinitely variable control.

As will be appreciated from the foregoing description, a vital feature of this system is that the relative velocities of the two slides at any instant is exactly proportional to the signals put out by the tracer head coils at that instant, so that control is stepless — a feature hitherto unobtainable by more conventional methods. So once again the electronic engineer has provided us with a latent accuracy of a very high order. But can we use it ? Without radical change in mechanical design, the answer is " no " ; but the changes envisaged are exactly those to which we have referred already, with one important addition.

This additional requirement is the suppression of backlash throughout the drive, more particularly, of course, in the latter stages of gearing and in the screw and nut. Tests of the " Spacematic " machine used as a copy-miller have shown that a small amount of backlash, purposely introduced into one feed motion, can be tolerated without loss of accuracy provided that the traverse speeds employed are relatively low ; as these increase, however, total elimination of backlash becomes essential. This is due to the fact that when the moment comes for a slide to reverse its direction, it is necessary for the motor to perform a number of revolutions in order to remove backlash before it can impart reversed motion to the slide itself ; however rapidly it does this, some finite time must elapse during which the other slide is still feeding, so that some error must result. At higher traverse speeds, the situation is aggravated by limitations to the possible rates of acceleration and deceleration of the motor and gear train.

As well as the additional requirement of the elimination of backlash, it is necessary to lay even more stress on the stiffness of the drive. An operator controlling the slides of a machine manually would complete small movements in, say, half a second, which might be accomplished by an electric motor in a tenth of that time or less ; consequently the accelerations imparted to the machine table increase one hundredfold or more, and with them the forces on the lead screw and drive. In effect, lack of stiffness introduces a time error so that the slide is always lagging behind the instructions given to it by the drive motor ; such time lags show up in the workpiece as dimensional errors, and these naturally increase with traverse speed. For example, if it takes one hundredth of a second for action by the drive motor to gain response from the table, then at a traverse speed of 60″ per minute a dimensional error of .01″ would result ; to this, of course, must be added further error due to the necessary response time of the motor to instructions from the tracer head, more particularly when rapid changes of direction are involved.

Recently we carried out tests on the "Spacematic" machine using a B.T.H. tracer head and control system, and some of the results obtained may be of interest as they emphasise what can be achieved by attention to mechanical design. We are able to copy-mill circles, for example, the profile of which lies within a tolerance zone of less than .0005″ ; a Talyrond record of a $3\frac{1}{2}$″ diameter circle, milled at 4″ per minute with a $\frac{1}{2}$″ diameter cutter, is shown in Fig. 13. It will be appreciated that this is a stringent test, as backlash has to be contended with four times in each piece and the direction of cutting is changing constantly through 360°. Another interesting example is that of the profile shown in Fig. 14, which was first generated on the " Spacematic " by plunge-milling to a series of co-ordinates. This master was then copied at 4″ per minute on the same machine using tracer control, and the Talysurf records of the two pieces, master and copy, speak for themselves (see Fig. 15).

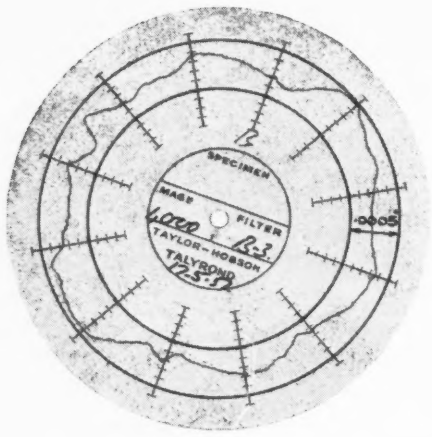


Fig. 13. Talyrond record of a circle machined by copy-milling; two concentric circles, .0005″ apart, have been drawn on the chart to assist interpretation.

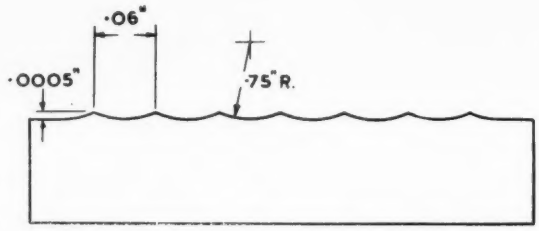


Fig. 14. Distorted sketch illustrating imaginary component generated on the "Spacematic" and afterwards copied on the same machine under B.T.H. two-dimensional control.

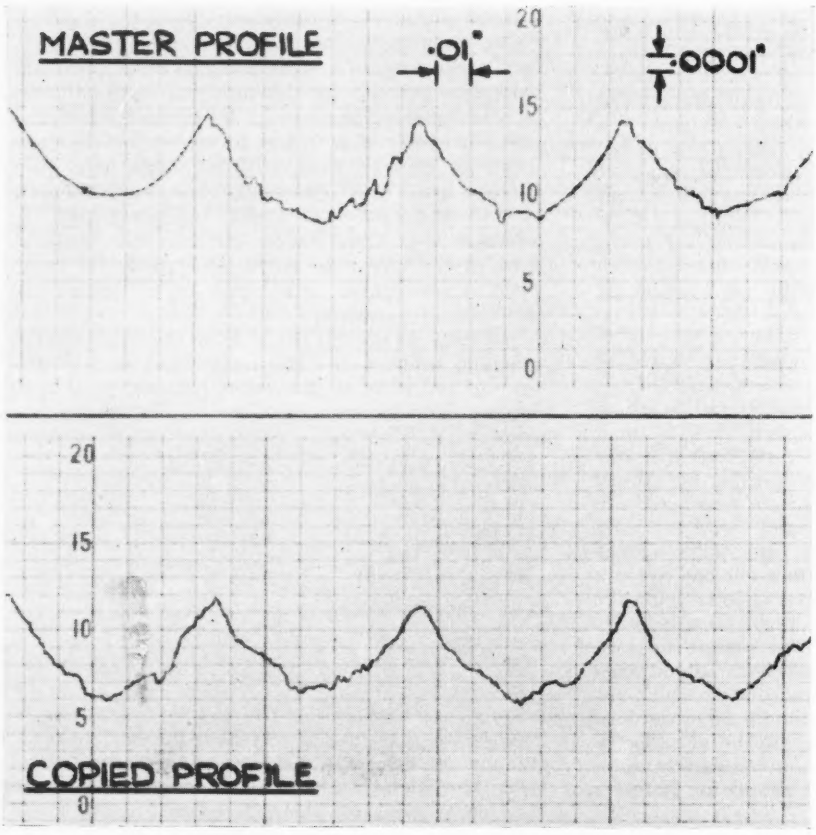


Fig. 15. Talysurf records of the profile illustrated in Fig. 14, showing the comparison between the original master and the copy.

Some people are of the opinion that tracer-controlled machines are becoming redundant with the advent of numerical control, but we believe this to be erroneous for a number of reasons:

1. The capital and running costs of numerically controlled machines are much higher than those of copy-milling machines.
2. For even simple forms numerically controlled machines require to be fed by computers, either directly or through some form of memory store — more expense.
3. In the field of press tools, the shape required is frequently determined by the appearance of a full scale model rather than by dimensions on a drawing or by equations to a curve.
4. There is no reason why forms should not be copied to the same order of accuracy and just as quickly as those created by numerical control.

These remarks should not be interpreted as meaning that numerically controlled machines do not have their uses, as this is very far from being the case. In fact, they will become quite indispensable in their own right, and will no doubt replace copy-milling in many spheres. But the need for copy-milling will still exist and, indeed, will be enhanced as high copying accuracies become more generally available.

Profile generation by numerical control

For many years it has been quite common practice to create high accuracy profiles, more particularly two-dimensional, by jig-boring methods. This is accomplished by taking a large number of closely spaced cuts at successive co-ordinates so as to produce a number of points lying on the required curve; the surplus metal left between settings has to be removed by hand, although depending upon its significance, closer spacing of cuts may avoid this necessity. Although a somewhat old-fashioned method by modern standards, it has been given a new lease of life with the introduction of automatic positioning from information punched on cards.

There are two reasons for this: firstly, automatic positioning combined with automatic card reading allow a very high rate of cutting (up to four or five points per minute) compared with that achieved by hand setting; secondly, the awful tedium of such an operation, which frequently led to the operator making a faulty setting when the job was nearing completion, has been eliminated by the combination of punched cards previously checked, and automatic positioning. The necessary co-ordinates can be calculated in the drawing office and hand-punched on cards in the usual manner, or certain general purpose computers may be fed with the necessary data and will put out the required information directly on punched cards to suit the machine tool. Accuracies, of course, are what one would expect from a jig boring machine.

A further development of this technique, which has been named "stair-case" milling, allows a milling cut to be taken during the actual auto-positioning cycle. When using this method the table moves to successive positions along alternate co-ordinates, the slide which is to move first being determined by an additional hole in one of two columns on the punched card. After pressing the card reader start button initially, the process continues automatically until ordered to stop. When the first card has been read, the additional punching mentioned will cause the appropriate slide to feed so that the cutter changes from position 1 to position 2, this slide then being clamped automatically (see Fig. 16); this causes unclamping of the other slide which then feeds until the cutter reaches position 3. Once again clamping takes place, and this causes the card reader to insert and read a fresh card (this takes only three seconds) which initiates the whole cycle once again. By this method it is possible to obtain about five contact points on the curve in one minute. It is also possible to generate three-dimensional forms by this method, the machine spindle being moved to successive vertical positions suitably spaced and successive "packs" of cards being used at each height setting.

Logical development of the above method results in true numerical control, in which the information is fed to the machine continuously instead of at comparatively long intervals. In this case, generally the required information is recorded by special computers either on magnetic or punched paper tape. A tape reading machine on the shop floor translates this tape information into continuous operating instructions which the machine tool obeys. In some systems, the complete instant-to-instant instructions are recorded by a computer which is quite independent of the machine, so that the former is working in its own time scale whatever that may be, and is therefore probably capable of supplying sufficient recordings to keep a number of machines busy. A possible disadvantage of this system is the lengths of

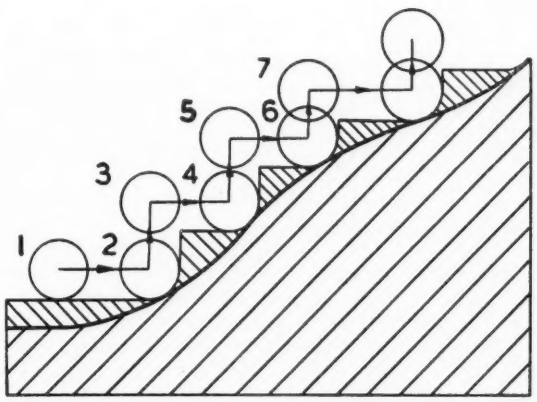


Fig. 16. Diagram showing principle of "stair-case" milling. The heavily shaded areas, if significant, must be removed by hand to leave the finished profile (shaded lightly).

tape required for complex forms, particularly three-dimensional. Other systems use a computer to calculate and record periodic points only along the curve, and the machine tool itself has its own smaller computer or interpolator which, running in the same time scale as the machine, calculates and transmits the slide increments necessary to join the recorded points by a smooth curve. This reduces the tape lengths to more reasonable proportions, but the basic cost of the machines, each of which require a computer, is necessarily higher. Both types of machine, of course, have their natural fields of utility.

This machine is analogous to the copy-miller, for both machine servo systems are operated by similar electrical signals ; in the one case these issue from magnetic tape, and in the other case from a tracer head. Consequently those design features concerned with slideways, drive stiffness and backlash are equally important to the numerically controlled milling machine. In practice the copy-miller presents a few additional problems such as rigid mounting of the tracer head in relation to the spindle, finding space to mount the model in rigid relationship to the work, and ensuring that machine vibrations are reduced to a minimum.

The mixture

In this Paper we have considered three basic methods of automatic control, viz. co-ordinate positioning, copying, and continuous numerical control. We imagine that already some of you are thinking : " If these three basic machines all demand the same attention to certain important mechanical features, why can't we roll them all into one ? ". Especially for the toolroom, this is the obvious answer. In fact the " Spacematic " *can* be supplied today to perform these three functions, although we do not pretend that our intermediate method of numerical control is as efficient as such control could be. But this latter drawback may be of minor significance when the overall versatility of the machine it given its proper assessment.

A further advantage of this merger is that between the three systems there is much common electrical ground, and the attendant saving in capital expenditure would be substantial. Where production volume warranted it, and these are just as much high production machines as tool-room machines, the individual types would still be in demand.

Where is the craftsman ?

This question must be in many minds today, and has certainly given some sections of the community much to worry about—surely quite unnecessarily. A machine tool, be it simple or highly complex, must be fed with information before it can produce. In bygone days this was supplied probably by word of mouth from the " boss ", through a skilled operator, to the machine. As complexity and variety increased it became necessary to record instructions on drawing paper, so that an additional skill was introduced and higher efficiency resulted ; but the craftsman still had to interpret the drawing to the machine. Further progress demanded the interposition of the skilled gauge-maker—and then the inspector. Considering complex shapes, the next stage was the introduction of yet another skilled man in the manufacturing process ; this was the model- or tool-maker who interpreted the information on the drawing board into solid form for the benefit of the skilled man on the copy milling machine. And finally we come to the continuously controlled machine in which the necessary instructions are recorded—probably on tape.

Between " tape " information and " model " information, however, there is one essential difference. In the case of the model, all the " shape " information is accessible at all times, and it is the operator who must decide how to use it by deciding on the cutting procedure, feeds, speeds and other operating conditions. Tape information on the other hand is only available in a particular sequence, and in most systems feed rates are determined by the tape. The operator's duties are reduced to those of setter-up and attendant.

This does not mean that human skill has been replaced by a machine, as before the magnetic tape can be recorded, a planner must determine the course and speed of every cut that is to be taken—an undertaking requiring all the skill of the machinist together with an imagination and conceptual ability of no mean order. Nor does it mean that the skill has been transferred from a mass of men to a select few —it is the men themselves who will have to be transferred from the shop floor to the office desk by a process of training and evolution.

The need for accuracy

Sometimes we are asked whether there is a real need for the accuracies we have been discussing. In the first place, there are now large numbers of components having tolerances on bore centres, for instance, which demand higher accuracies than can be achieved with jig-guided tools, even though the jig in itself may be precise. For such components the only solution is to cut out the intermediary and perform the work directly on a high precision machine tool. This field is extending daily, more particularly in the aircraft, armaments and atomic energy industries, and is not likely to diminish.

Next we have components coming in the .002" to .005" tolerance range which can be handled satisfactorily by good jigging. In these cases the jig itself has to be made, and in accordance with accepted and proper practice this will be to a limit five to ten times better than the component it has to produce. So, still we have the need for accuracy.

And, lastly, we have the ever-increasing tendency to dispense with jigs altogether : they are very costly items, particularly for small batch production; they are subjected to continual wear and abuse; and they impose serious limitations to design modifications — very frustrating in these days of rapid change. Many factories today, ours being one of them, have a line of jig borers in the open shop engaged solely on

component manufacture. This emphasises what we have said previously, that even comparatively low accuracy components may demand the ultimate from the machine.

When a machine is working right up to its own accuracy limits, it is bound to produce, if "produce" is the right word, a higher percentage of scrap. This is on account of many small variables each adding their own errors: sometimes these tend to cancel out favourably, but mostly they seem to accumulate to excessive amounts. Typical examples are indifferently-sharpened drills and reamers producing holes off centre; lack of homogeneity in the work material which may cause the same result; bad work preparation so that the work distorts on clamping; careless positioning of clamps; lack of control of temperature both of the machine and its surroundings, and of the heat added to the work during cutting. In themselves these errors can soon become significant, but if we add to them basic machine errors then the scrap-bin is soon full. It is these last errors which *can* be controlled and kept to an absolute minimum by high precision machines, preferably automatically controlled, so that the user has as much latitude as possible to scatter his tolerances where he will.

The final contributor to the scrap-bin is our unreliable human being who can still make an error in setting, and as the day wears on, conscientious as he may be, fatigue is more and more likely to cause him to do so. This potential source of scrap, fatigue, is eradicated by automatic control.

The impact on inspection

Automatic control is likely to have some quite revolutionary effects upon work inspection. And certainly the time is ripe for a revolution, for increasingly we are being faced with the absurd situation that a component is produced in two hours and then takes two days to check. Should it be wrong, that is two days, two hours and a lump of metal wasted.

In the first place, it is necessary to accept without question that a well-designed automatic machine will do exactly what it is told within its own inherent limits of accuracy, and if for any reason is should not do so, it must either signal the fact or "fail to safety". This is a matter of design, but it can be achieved. Doubting gentleman that he may be, and should be, in time the inspector will come to accept this also. So we put to you the revolutionary idea that the inspector should do 95% of his checking before the component is even started.

In other words, it is the planning operation and the associated punched cards or tape which should receive inspection's main effort, for thereby we have a triple saving. Firstly, the factory does not waste time and material in producing faulty components; secondly, the inspector does not waste time inspecting them; and, thirdly, it is only necessary to check punched cards once no matter how many components are produced from them.

The inspector's secondary function will be to check holes for size, as this dimension is not under the control of the machine, but this is a relatively rapid task. Components produced by numerical control should only need one or two simple checks to determine that proper compensations have been made for cutter diameter.

Maintenance

This question looms very large in the minds of many users today. It is probable that most of our doubts about electronic reliability have been caused by occurrences during that unfortunate period just after the War, when the market was swamped with electronic "gadgetry" of all kinds and for all purposes. In the first place, the bulk of this was produced by companies new in the field who had no practical experience of industry's requirements, or of the conditions in which their apparatus would have to function. Secondly, most equipment was based on the use of standard radio components, which were neither rugged enough for industrial duty nor designed for the types of functions they were expected to perform. All this led to electronic equipment generally being condemned as extremely unreliable and suitable only for receiving the weather forecast, and as this was usually inaccurate, a breakdown was of no importance anyway. We were caught in the same snare and had to replace a number of jig borer and grinder main drives at some considerable expense.

Fortunately, now the situation is entirely different and rugged and reliable components are in common supply: new developments such as transistors will enhance the situation further.

Notwithstanding the above it is still reasonable of course to expect some breakdowns to occur, generally of a simple nature. Three things can help to deal with this problem:

1. The provision of built-in checking facilities for those parts of the circuitry most likely to fail or to require occasional adjustment.

2. The splitting up of the circuit into sub-units which, upon failure, can be interchanged rapidly for a replacement unit. The facilities mentioned in 1. above should serve to point out the faulty unit.

3. The running of short instructional courses for ordinary maintenance electricians, of about two weeks' duration, either at the machine builder's works or at those of the electrical company concerned; this is to train them to be diagnosticians and not electronic engineers.

Given the above facilities we think there will be no difficulty in the maintenance problem. Bear in mind too that it is synonymous with progress that the user must trail a little behind the innovator, and that Mr. Newcomen must have been in heavy demand for his services in the early days of the steam engine.

Fig. 17. Aircraft component completely machined on the "Spacematic" in 10% of the time taken by previous methods.

The cost to the user

This heading alone could give rise to a further series of Papers, so here we will be brief and recognise that many of the arguments that could be put forward are the same as those that apply to automation as a whole; as the whole object of automation is to reduce the cost of the final product, we are wasting our time if we do not accept this as a fact.

Unquestionably capital costs of such machines as we have been discussing are high. Apart from that portion wrapped up in the machine itself due to more expensive mechanical details, higher inherent accuracies, more rigid construction, better control facilities and extensive interlocking, there is also the basic cost of the electronic control equipment which can easily amount to between 30% and 50% of the ultimate selling price, which itself may be double that of a hand-setting machine. But it is easy for these increased costs to be saved by:

1. A machine spindle that spends most of its life cutting instead of waiting for an operator to plan his next action and prepare for it. Even during the positioning movement he can be changing his tool, gauging a hole or removing swarf.
2. The time normally spent in checking and rechecking settings being eliminated.
3. Lessening of operator fatigue with consequent higher productivity.
4. The elimination of jigs.
5. The reduction of scrap to a negligible level.
6. The saving of inspectors' time, which also allows faster work flow.

Any one of these reasons would compensate for the increased interest on capital invested and the consequent increased depreciation. Some of these factors are difficult to measure directly in terms of money, but others appear as a direct saving in the floor-to-floor time and these can be illustrated by quoting two typical jobs which have been machined on the "Spacematic" recently.

The first consisted of a die plate containing 260 holes spaced one inch apart in both co-ordinates. The hole diameters were .25" and the depth .3". The tolerance between any two holes over the 26" × 10" area was ± .0005", measured either normally or diagonally, and between adjacent holes, .0003". In view of the fairly close limits it was decided to centre-drill, drill, rough bore and finish bore each hole—that is, four operations per hole. The total time taken was just under nine hours, that is two minutes and four seconds per hole, which compared with thirty-three hours normally taken on a standard jig boring machine. This die has a comparatively short life and consequently is produced in quite large quantities; the installation of an automatically controlled machine here would avoid the necessity for three conventional jig borers.

Another example depicted in Fig. 17 is a magnesium jet engine component having a total of 130 holes of sizes ranging from $7\frac{3}{4}$" diameter downwards. This was machined in under six hours, which compared with a conventional time of 57 hours. This direct saving alone is phenomenal, but to it must be added the saving of a complex jig which itself would have to be recovered over a comparatively small production.

The cost to the machine tool builder

This point deserves some mention as the situation may become embarrassing as time goes on. The cost of producing prototypes of these machine tools is very high indeed. Admittedly perhaps the greater portion is borne by the electrical companies themselves, provided that they can envisage an eventual return for their investment, and on account of their size they are better able to do so. But the smaller units within the machine tool industry may well find it difficult to raise the necessary capital not only to push forward development to the degree one would like to see, but also to carry adequate stocks of expensive control equipment; such stocking is essential in order to be able to offer reasonable delivery periods to the user. Perhaps as time goes on development contracts will have to be extended also into the machine tool industry.

The machine tool industry will not, however, be in a position to continue to promote extensive developments unless users discard outmoded plant and take fuller advantage of the opportunities created for them to improve production efficiency.

Mutual support between the engineering industry and manufacturers of machine tools is imperative, otherwise it is inevitable that stagnation will result as the latter will be unable to engage any capital commitments in development work.

APPENDIX A

The B.T.H. Automatic Co-ordinate Setting and Control System

This system consists of servo mechanisms operating in the two axes of the motion, the input to which is set up on dials. Six dials are provided for each of the two ordinates, and on these may be set the required displacement in tens of inches, inches, and decimal parts of an inch (e.g., 14.5693″) from a predetermined and readily adjustable datum. The dials may be set by hand or by using punched cards automatically fed through a card reader on the control desk; whichever method is used, the selected dimension is clearly displayed (see Fig. 2 in the main text). One card is used for each co-ordinate which facilitates modifications either to operation sequence or to individual co-ordinates on account of design changes, and permits all machining instructions relative to the particular position to be included on the card itself if required.

The electrical measuring system comprises a rigid measuring bar, manufactured from corrosion-resisting steel, which is accurately divided into one inch reference units. This is mounted on the machine sliding member. Mounted on the bed of the machine is an electro-magnetic detecting head which co-operates with the measuring bar and supplies an electrical misalignment signal to the control system. The one-inch units in the bar each have a $\frac{3}{4}$″ diameter hole bored in them, and it is the effective magnetic centre of this hole which the detector head is able to sense. The diameter of the hole is not critical; it is filled with a piece of non-magnetic material so as to present a smooth surface which is in contact with wipers surrounding the detector head. The magnetic centre of the inch units can be adjusted by asymmetrical steel slugs (see Fig. 18); this is done after final calibration in the finished machine tool, the accuracy of setting being limited only by the calibrating instrument employed. The detector head is essentially a differential arrangement of two 50-cycles per second transformers, and, its construction being symmetrical, it is free from changes caused by temperature, supply voltage and frequency, or stray magnetic fields; its stability can be relied upon to ± 10 micro-inches.

The detector head, weighing only a few ounces, is mounted in a kinematically design ball-slide and can be shifted by means of a substantial micrometer screw of $\frac{5}{8}$″ diameter and having 20 t.p.i, co-operating with a bronze nut having a self-adjusting backlash eliminator. The hardened screw, which is journalled at both ends, and the nut run in a bath of constantly changing oil, and in view of this and the negligible force required to move the detector head, its life should be indefinite. The periodic pitch error of the screw is within 20 micro-inches and accumulative pitch errors are compensated for electrically.

The micrometer screw is driven by an accurate instrument servo mechanism through a range of two inches; one inch of this travel is used for zero setting purposes, so that irrespective of where the component may be positioned on the machine table, the required datum hole or face may be designated 00.0000″; the other inch of travel is used to determine the "decimal" part of a required co-ordinate shift (the measuring bar providing the integral inches). As a precautionary measure against possible temperature effects on the machine, the power supply to this unit is automatically shut off when it is not in use. The complete unit is illustrated in Fig. 19.

The controlling action will now be described as a sequence, although in practice certain motions take place simultaneously; reference should be made to Fig. 20. Setting the required dimension on the six dials on the control desk causes rotation of the input synchros S_1, S_2, S_3 and S_4 and these give misalignment signals in co-operation with the corresponding output synchros T_1, T_2, T_3 and T_4 respectively. The "decimal" portion of the dimension is

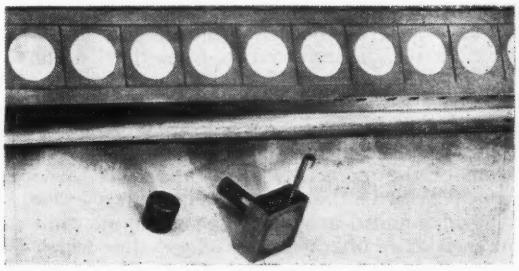


Fig. 18. Portion of B.T.H. measuring bar. Also shown is one of the "inch" blocks from which one of the trimming slugs has been partly removed.

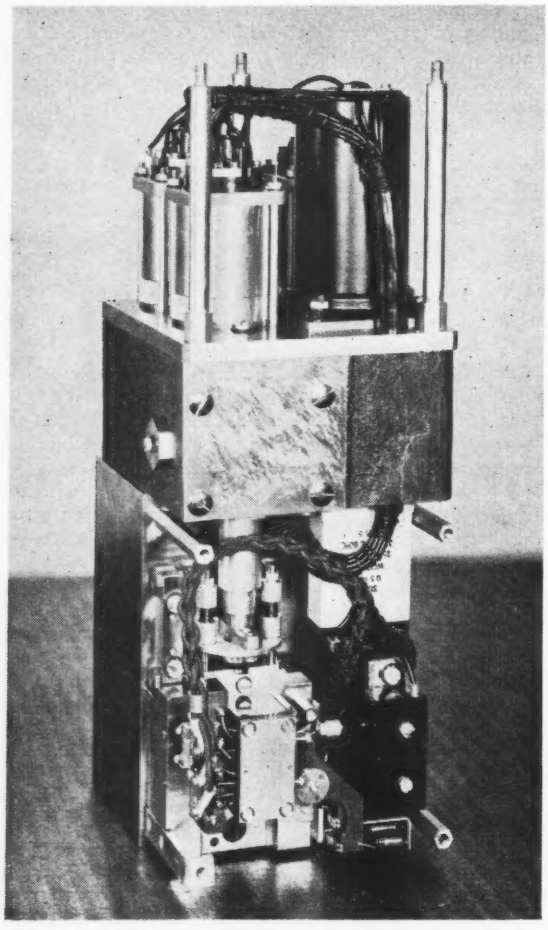


Fig. 19. The B.T.H. detector head with covers removed.

defined by shaft rotation of S_2, S_3 and S_4, which causes the servo amplifier A to drive motor M_1 until S_2—T_2, S_3—T_3, S_4—T_4 are in alignment; the detector head will now be in the required decimal position.

The "integral inches" part of the dimension (together with a contribution from the "decimal" part) gives a rotation of synchro S_1; this is electrically connected with synchro T_1 which is geared to the main table drive lead screw. A misalignment signal from S_1—T_1 controls servo amplifier C, and by means of the motor M_2 brings the table to within about 0.2″ of the desired position, the traverse speed being maintained at about 90″ per minute until the last inch or so of travel is reached, after which the speed is progressively reduced. Control of M_2 is now transferred, *via* a relay and the servo amplifier B, to the electro-magnetic detector head; at the same time there is an automatic increase in the reduction gear ratio between motor M_2 and the machine lead screw. The control signal from the detector head drives M_2 until the poles of the head are aligned opposite the nearest inch unit in the measuring bar; under these conditions the error signal from the head becomes virtually zero. The sensitivity of the head and its amplifier is such that it is capable of delivering a voltage sufficient to operate the servo motor M_2, and hence drive the machine table, with only 15 micro-inches of misalignment.

During the approach to alignment under the control of the detector head, a temporary misalignment signal is injected into amplifier B, so that the table travels to a "false" alignment position, approximately .02″ from "true" alignment. The temporary signal is then automatically removed and thus the final approach to alignment is always from the same direction. The "error" signal from the detector head is proportionate to the displacement from the desired position, and reverses in phase for an error in the opposite direction. This permits the final approach to alignment to be made under conditions of controlled velocity and retardation of the table, so that the manner of stopping is predetermined by the electronic circuits, and not by extraneous conditions such as viscosity of lubricants, table loading, etc. An additional advantage is that backlash in the drive is of no importance.

After completion of the above cycle, and immediately prior to automatic clamping, motor M_2 reverses for a fraction of a revolution to remove any stress from the drive.

From the preceding paragraph it will be apparent that the table always moves directly from one position to the next, whether the latter be to the left or to the right of the previous position, but passing first through the "false" alignment position. Thus, in the case of a displacement in the negative sense, say from 20″ to 10″, the table will first automatically retract to the "false" alignment position which will be at 9.9800″, and then advance by .02″ to the "final" position at 10.0000″. Similarly, advances (or retractions) by small amounts are performed in the same manner: for instance to move to a position .0001″ further ahead, the table will first retract an amount of .0199″ and then move forward .02″ into position; similarly a negative displacement of .0001″ will be performed by retracting .0201″ followed by an advance of .02″.

After the required dimension has been selected on the digit dials, automatic setting is initiated by a push button, and the sequence ends by automatic clamping of the table. This is indicated by a signal lamp, and a further check is provided by observation of a sensitive meter which indicates detector head coincidence. Both slides, of course, can be set simultaneously. The total setting time for fractional parts of an inch is about five seconds; 6″ is accomplished in 10 seconds and 24″ in 21 seconds approximately.

It will be noted from Fig. 20 that the dials on the control desk are coupled to the synchros through differential and other gearing, in such a way that

the addition of one unit in say the .01″ dial will not only give a certain rotation to S_3, but also will cause synchro S_2 to rotate by one-tenth of this amount—without of course moving the .1″ dial. Thus the differentials serve to add one-tenth of the rotation of any dial to that of the shaft behind the adjacent dial on its left hand side, and this in turn adds in one-hundredth of the original rotation to the next dial, and so on. This is necessary for the following reasons:

1. For a given setting the same apparent relationship must exist between S_2, S_3, S_4 on the desk and T_2, T_3, T_4 on the machine. The latter synchros are connected together through a normal gear train, but a similar arrangement would be unsatisfactory in the desk, as it would mean that the operator would have to rotate the right hand dial through 1,000 revolutions to apply an increment of one inch; this would be neither convenient nor speedy. It is preferable that, to the operator, the dials should appear to work independently.
2. Differential coupling is also used to the left of the decimal point, so as to ensure that no ambiguity arises if the settings of input dials are changed from, say, 10.0000″ to 10.9999″. This would cause the detector head to be moved very nearly into alignment with the 11th unit on the measuring bar. It must *not* however be aligned with this unit, but with the 10th. Therefore, the synchro S_1 is rotated through the differential by an amount which corresponds approximately to .9999″ which, through the servo motor M_2, brings the table nearly into the correct position as previously described.

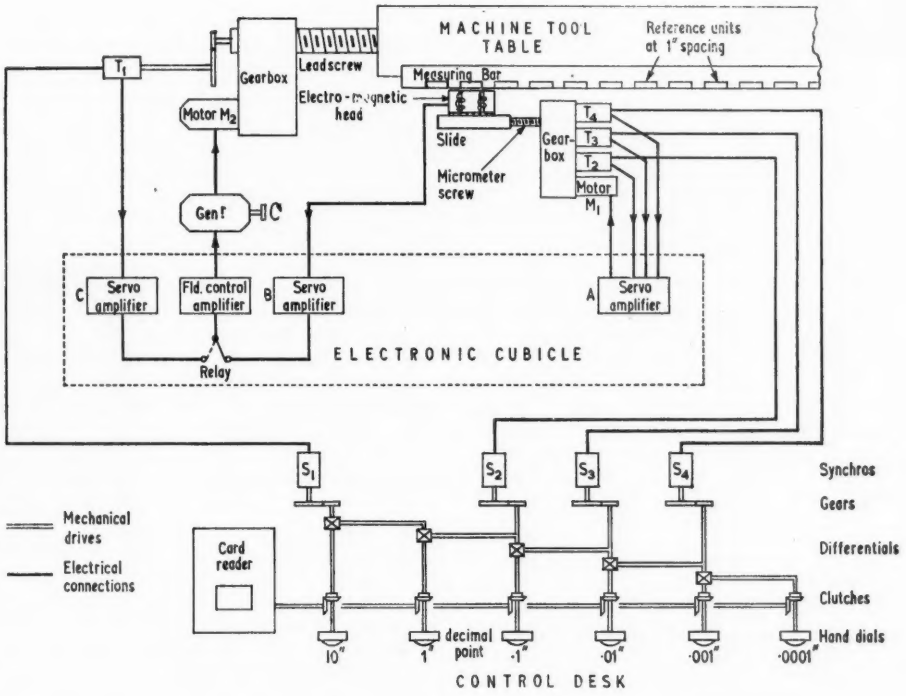


Fig. 20. Schematic diagram of B.T.H. electronic position control system.

TRANSFER PRESSING

by GORDON M. SOMMER

and

ROBERT H. BARLOW.

Mr. Sommer, who is Chief Development Engineer of the Clearing Machine Corporation, has been with the Company for eight years, and prior to his present appointment was Chief Engineer of the Hamilton Division.

He has supervised the design of presses ranging from small 30-ton inclinables to giant 4,000-ton rail presses weighing over one-and-a-half million pounds, and is recognised in the industry for his analysis of deflection characteristic of press structures. More recently, he has been chiefly responsible for the development of the many new automation concepts incorporated in the Corporation's products.

Mr. Sommer spent several years with various engine manufacturers as a tool and die designer prior to his association with the Clearing Machine Corporation, and owned and operated a company engaged in the design and manufacture of material handling equipment.

Mr. Barlow is Technical Director of Foreign Operations for the Clearing Machine Corporation of Chicago, and is based in London and Paris. He has wide experience in the metal stamping field, and until joining Clearing recently, was Manager of the Plant Engineering Department, Metal Stampings Division, of the Ford Motor Company, where he had worked since 1947.

Mr. Barlow had previously spent 10 years with Fisher Body Division of the General Motors Corporation, as master mechanic, and as works manager, and has also spent equal amounts of time with the Budd Company and Chevrolet in various engineering capacities.

IT is now well known that several years ago the automobile concerns in America, faced with an ever-growing demand for their products, recognised the imperative need of finding some means of increasing production, safely and economically. As a result, they developed the idea of producing parts in large volume on automatic machines; this development has come to be known as automation, or automatic production, and is now in wide and increasing use all over the world.

The tremendous advantages to be gained from automatic production can be clearly illustrated by one example, where a transfer press was introduced to make a certain part for a car engine. Before the advent of the automatic machine, one automobile plant used six 84″, 300-ton, straight-sided presses

to produce this part. With the introduction of a transfer press, it became possible to make the complete part on one machine.

The benefits gained from such an innovation are to be found not only in greatly increased production, with subsequent cost reduction, although this is very marked. The saving in floor space can be considerable, and in this particular instance amounted to some 50%. Also, the need to move parts and materials is reduced sometimes almost to vanishing point. In the example just quoted, the saving in materials handling was estimated at 75%.

Importance of safety

But one of the most important developments resulting from the introduction into a plant of such manufacturing aids as transfer presses — indeed, perhaps the most important — is the fact that each worker's 'zone of safety' is inevitably increased. With automatic controls, it becomes unnecessary for the operator to approach a machine in motion.

This safety angle is particularly stressed, because no matter how great our technical advances, we can never build anything so marvellously contrived as a human being. Neither are we able to replace any part of a human being — not so much as a little finger — should it be destroyed in an accident caused by machinery of our invention.

Following the introduction of transfer presses into the automobile industry, and the revelation that their adoption did indeed bring about the benefits claimed for them, presses were installed in growing numbers for the complete manufacture of a great variety of different products, such as refrigerators, air-cleaners, hub-caps, valve rocker arms, car heater parts of all kinds, washing machines, drying machines, dishwashers, and radio and television parts.

It is essential, of course, that a properly oriented approach to efficient stamping production must include several vitally important factors. Not only must a means be provided to produce stampings at a high rate of production with a minimum of manpower, but means must be provided to reduce to an absolute minimum the change-over time from the production of one stamping to another.

This change-over must be accomplished in minutes, rather than hours, and furthermore automatic press equipment must be completely flexible, which means that the equipment must be able to produce a variety of stampings today, and a completely new or redesigned product tomorrow. These three concepts— automatic transfer and handling of stampings; rapid change-over time ; complete flexibility and versatility — have been borne very much in mind by our Company in designing and building their latest equipment, and have not only dictated new mechanical design of presses and press equipment but, equally important, indicate a completely new approach to press plant design and/or operation, for maximum utilisation of the benefits of these concepts.

Automatic transfer and handling of stampings

It has long been recognised that transfer type presses are singularly adapted to efficient high speed production, and in fact these presses have been used in Europe for some time, although only for the production of small components. Transfer presses are designed to perform numerous operations on a component and thus produce the completed part within one press. In this type of press, the part is transferred from station to station by a feed mechanism, which is mechanically driven from the press itself.

Synchronisation of the press and feed mechanism is automatic and consistent. There are no limit switches to be tripped, no relays to operate, no air valves to actuate and no air cylinders which must be timed. Compare this with the typical automatic press line which requires that dozens of limit switches, relays, air valves and cylinders be operated every time a part is produced. Malfunction of any device puts the press line out of operation until repairs or adjustments are made.

Another shortcoming of this type of line automation is that the part is pushed, pulled, shoved, flipped and conveyorised. This means that control of the stamping is often lost between each press and must be relocated for each operation. This all adds up to relatively inefficient automation.

Transfer press type of automation consists of very definite right angle motions, which give positive and accurate indexing of the part. The part is always under positive control and is the reason for the greater efficiency of this type of automation. Our basic concept of press line automation is that a line of presses is essentially one big transfer press, with only the station centres increased, and should be automated in exactly the same way.

The major difference between our first approach to this type of automation, and our present practice, is that only one mechanical source is used to power the automation for a complete line of presses, when the line is less than 75′ long. The mechanical source is similar to the feed operating mechanism of the Transflex press, which will be discussed later. The feed operating mechanism for line automation is driven continuously by a variable speed motor through a clutch and brake unit. The presses are single-stroked by the feed mechanism. In this way, the speed of the press line can be changed and the presses and feed inched independently. None of the features of flexibility of the wheel line is changed by the new approach, which is simpler and will require less maintenance and adjustments.

The photograph in Fig. 1 gives a general view of a single-slide Transflex press of 500 tons capacity, and was taken on our assembly floor. The bed area is 148″ × 48″ and the feed direction is right to left, with an adjustable stroke of 15″ to 30″.

The feed drive housing is mounted at the left end of the press and is powered from a single shaft, connected to a main pin in the crown. Feed stroke adjustment is made at floor level, by removing the rectangular cover at the end of the drive housing. All parts of the transfer mechanism, with the exception of the finger mechanism in the die space area, are fully enclosed and lubricated from the press recirculating oil system.

The photograph shows how the air cylinders, for knockout, are mounted in gib ways in the slide and

can be adjusted right to left. The positive knockout rods were not assembled when the photograph was taken, but mount in the track mounted on the bottom of the crown and can, likewise, be adjusted right to left.

These presses are equipped with variable speed motors and have a top speed of 32 strokes per minute. The feed is very smooth, even operating at the top press speed with the 30" feed stroke. This is about twice as fast as anyone previously thought possible or practical.

Fig. 2 shows the transfer bar design in the press, and depicts the ruggedness and rigidity of the transfer mechanism. The large drive tubes are oscillated back and forth to obtain the right to left transfer motion, and are supported every four to five feet by the housings that carry the racks. These housings ride on two hardened and ground shafts. The in and out, or clamping and unclamping, motions are attained by rotating the tubes. Lengths of aluminium channel are mounted to the racks which move in and out, upon which the finger carriers are mounted.

This design completely eliminates the problem of inertia found in conventional transfer feed bars employing rectilinear motion. It is thus a very simple matter to adjust the location of the fingers. It will be noted that the drive tubes and aluminium channel are made in incremented lengths, so that the mechanism can be easily removed for die setting, thus making it possible to attain much of the flexibility inherent in the Transflex design. An important feature is that all the mechanism is mounted outside the bolster area, which can be used for dies. This feature is exclusive to our presses.

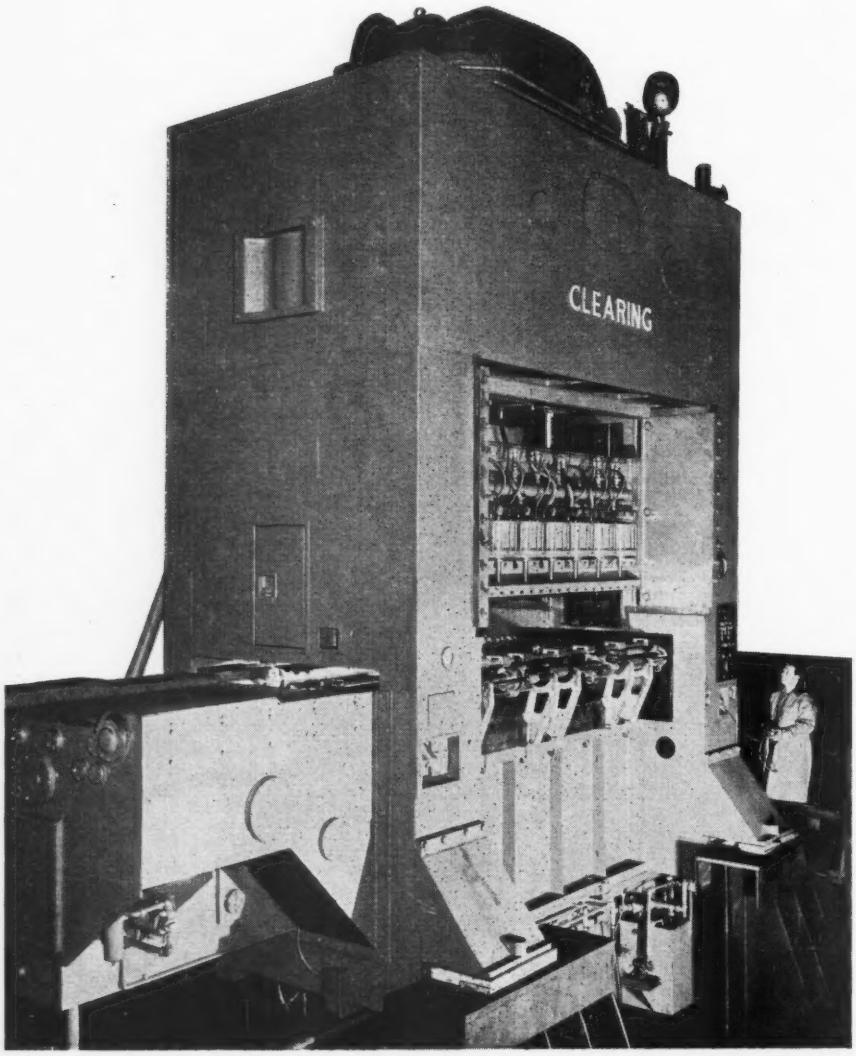


Fig. 1. Single-slide Transflex press of 500 tons capacity.

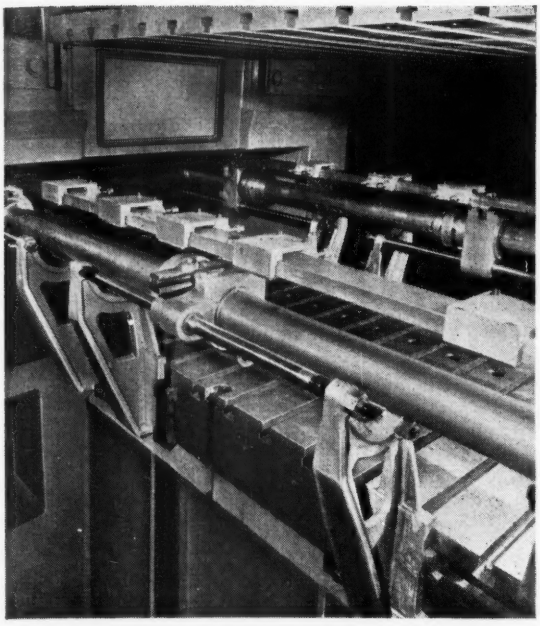


Fig. 2. This photograph shows the transfer bar design in the Transflex press.

Fig. 3 is a photograph of the bottom of a Transflex press, and shows how the cushions are adjusted right to left. The cushion supports are mounted in gib ways, at the bottom of the press bed. Each cushion can be individually adjusted, by rotating the handwheel.

The schematic sketch in Fig. 4 shows how we obtain our transfer motion. Power coming from the crown is used to rotate the two hardened double-face cams. One cam is for left to right motion — the other for clamping and unclamping. There are no overhanging parts, and the cam followers are always contained.

The smoothness of the transfer motion, which was mentioned earlier in the Paper, has been attained by employing high speed camera studies to get master cams with flawless acceleration and deceleration rates, from which our production cams are made. In this way we have been able to get a transfer motion which can be matched by no other method. The smoothness of the transfer motion and the rigidity of the transfer bars determine how accurately the work-piece can be transferred and how fast the transfer press can be operated. Feed stroke adjustment is made by simply rotating a single screw.

The conventional transfer press automation consists of two motions — a clamping and unclamping motion, and an index or transfer motion. This has always limited the transfer press automation to parts with a comparatively flat flange or edge. A recent Company development introduces a third, or 'lift', motion to these mechanisms. It is now possible to use this type of automation with virtually any type of stamping. It is adaptable to either the transfer

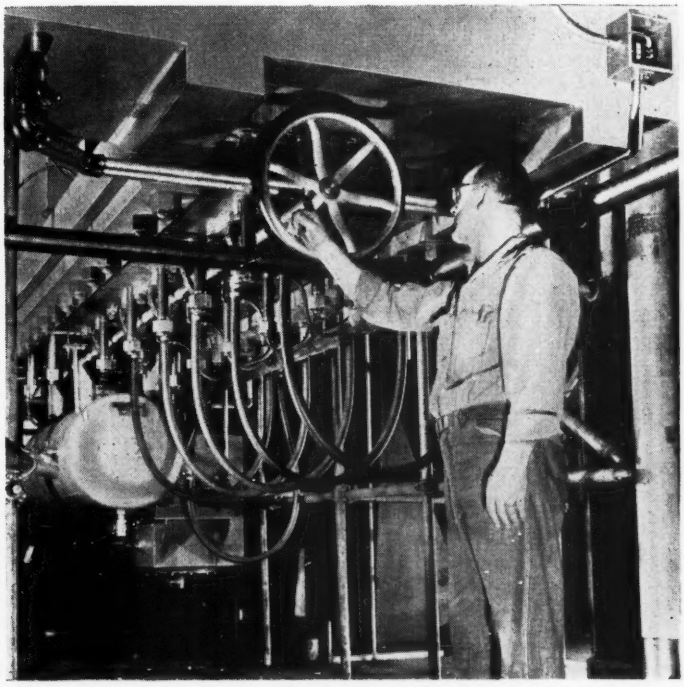


Fig. 3. The bottom of a Transflex press, showing how the cushions are adjusted right to left.

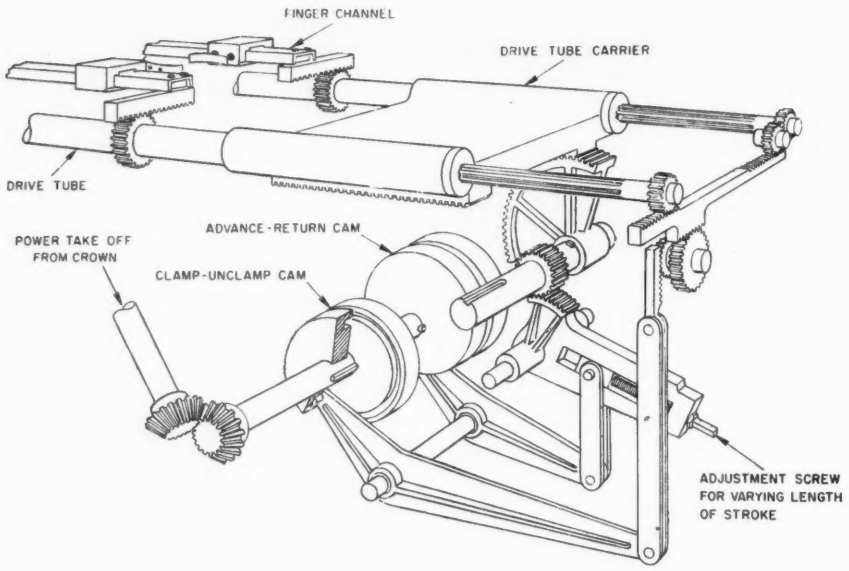


Fig. 4. Schematic drawing illustrating transfer drive.

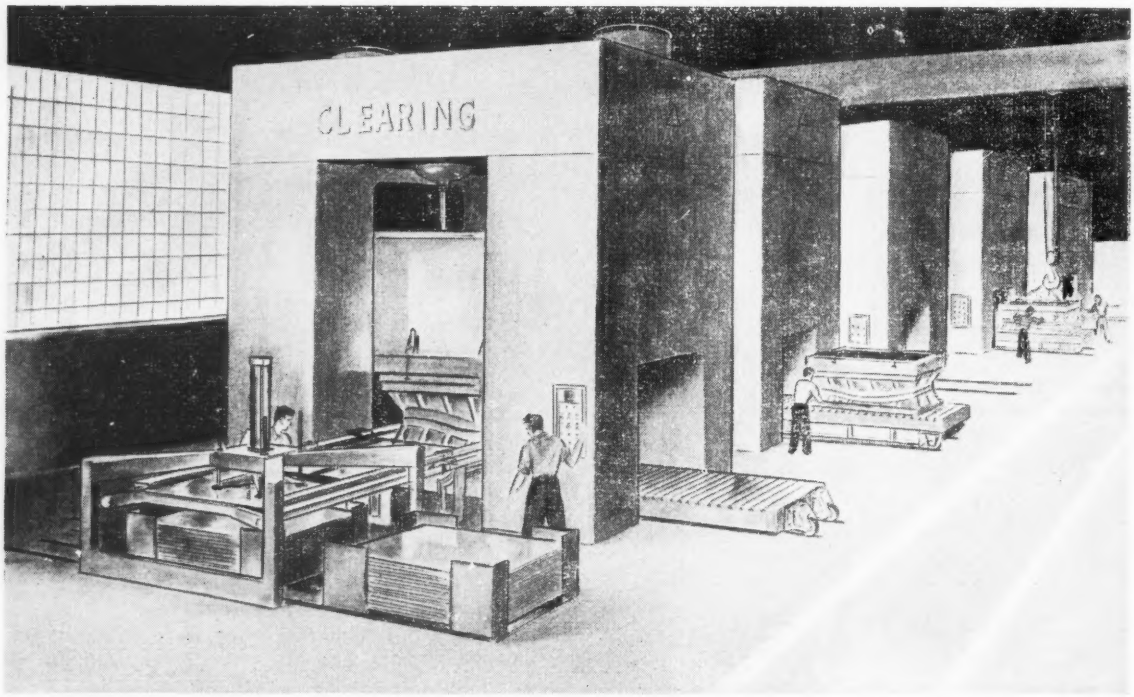


Fig. 5. "Push-button" die setting, used in changing parts in a press or line.

press or the automated line. A single source is used to power all the automation, including a turnover for a complete line of presses. Only one limit switch is required for the press line synchronisation. This means that for the first time automation of complete lines of presses can be as precise and efficient as a transfer press.

Rapid change-over time

In addition to having automatic equipment that is precise and efficient, we must be concerned with the press utilisation time, i.e. the length of time taken to change from the production of one part to another. It does not make sense to produce parts automatically, at a high rate of production, for eight hours, and then take several hours to change to the production of a new part. We have just developed "push button" die setting, so that this change-over time can be reduced from hours to minutes. "Push button" die setting makes it entirely feasible to change the part in a press, or line, as here described, every four to eight hours (Fig. 5).

A great deal is being said these days about the advantages of integrated production. Integrated production means that parts are produced only as required, thus eliminating large stockpiles and inventories. Since it is obviously not possible to have a separate production line, or transfer press, for every stamping that must be produced, it becomes equally obvious that press lines and transfer presses must be equipped with means for quick die and automation changes, if integrated stamping production is to become a reality.

With "push button" die setting and Transflex automation, change-over time is reduced to a minimum. The old dies are removed and the new one secured in the press completely automatically and by push button control. Since the dies are loaded at right angles to the flow of work, and since Transflex automation consists of straight line motions, the automation change-over consists merely of replacing new sets of feed channels. These channels, with the appropriate feed fingers, become a part of the tooling set-up and are, in essence, a part of the die equipment.

A press so equipped has essentially two specially-designed bolster structures, which are mechanically connected, and are power-driven to the right or left through the press uprights (Fig. 6). The complete die can be placed on the bolster structure, while production is being run in the press. The bolster is designed so that standard pressure pins can be placed outside the die space area and the lower die shoe completely secured. After the production run is completed, the bolsters are powered to the left. This removes the die, which has just been used, and places the new die in the die space area. The old die is now located to the left of the press. This old die can be removed at any convenient time and replaced by another die, for another production run. The bolsters are moved to the right for the next production run.

Dies thus can be changed in complete lines of presses simultaneously, without any waiting for overhead cranes, or die trucks. The punches are clamped

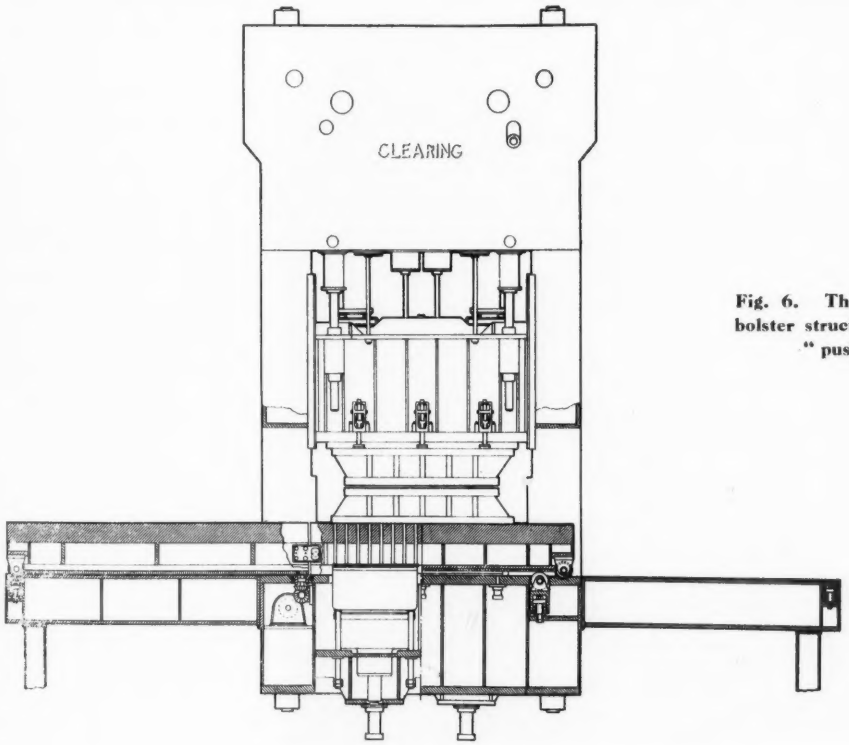


Fig. 6. This drawing shows the special bolster structure in a press equipped with "push-button" die setting.

to the slide, or slides, by the use of automatic or semi-automatic punch clamps.

A major automobile manufacturer has found, by a detailed study, which has just been completed, that the change-over time from the production of one part to another will take only one-quarter as long on a press line equipped with "push button" die setting and Transflex automation, as on a conventional type of automated line. The savings possible with "push button" die setting on transfer presses should be even more startling.

Since a basic principle of "push button" die setting is to load the dies at right angles to the flow of the part, the moving bolsters are operated front to back in a Transflex press. The advantage of this concept is that an absolute minimum of automation is removed for die setting. Two sets of feed tubes and channels are mounted on the bolsters, so that the feed fingers can be mounted and adjusted, as well as the dies, during press operation. The feed tubes can be readily coupled together during the change-over time.

To appreciate fully the impact of "push button" die setting in a particular stamping plant, and to get a picture of how it would affect production costs, it is strongly urged that manufacturers compare the net and gross cost of their stampings. By "net" is meant the actual cost of producing stampings, based on per hour cost of press and including direct transfer to the assembly line. Press cost should be pro-rated without any factor for percentage of utilisation.

Gross cost would mean the cost of the stampings, as delivered to the assembly lines, and include all handling and storage costs, die setting and so on. Many companies find that the gross cost is usually more than double the net cost. When thus analysed it is usually found that "push button" die setting offers as much production savings potential, by greatly increasing press utilisation and reducing stockpile requirements, as does automation.

One of our latest productions, which has just been shipped, is an immense Transflex press for the manufacture of washing machine and drying machine tops. This monster has an overall length of 58′ and has five slides. It has a transfer feed stroke of 40″ and will produce more than 700 stampings per hour. Washer tops will be produced for four

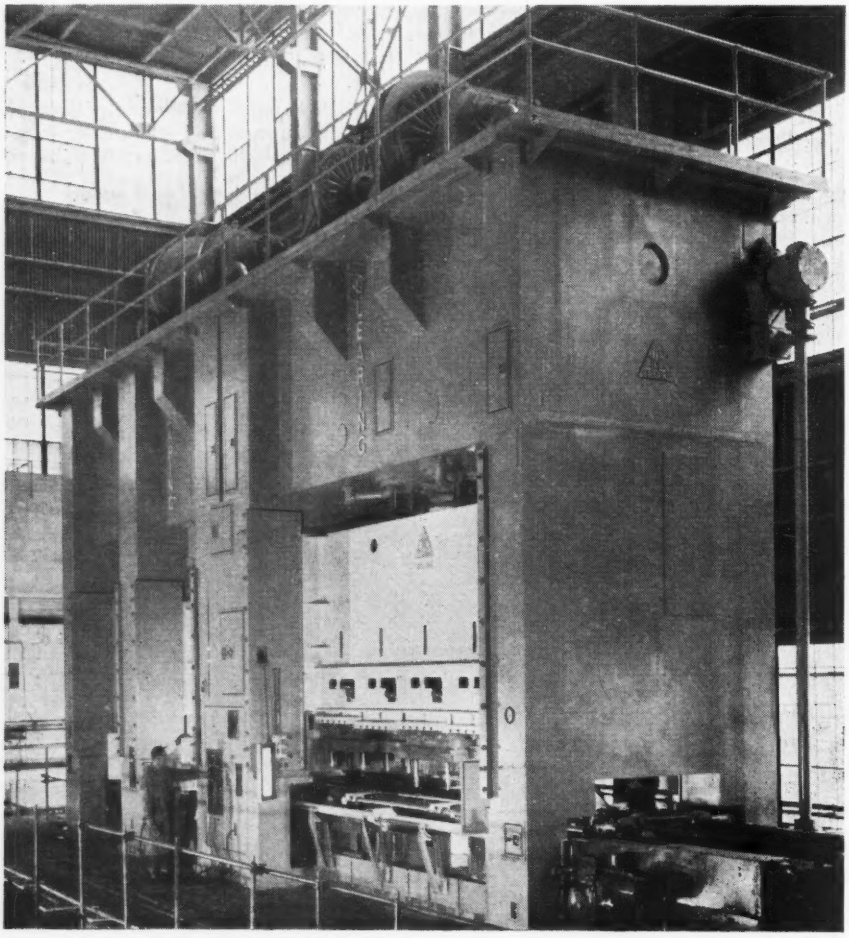


Fig. 7. Transflex press for the manufacture of washer and dryer tops.

hours, when production will be changed to dryer tops, in less than 10 minutes. Dryer tops will then be produced for a four-hour period, and there will be a 10 minute change back to washer tops, and so on. (See Figs. 7 and 7A).

How the press was developed

This press, as it now stands, incorporates many advanced concepts of flexible automation. These were not all envisioned in the initial stages of development. In fact, some of the concepts were evolved to meet the specific production problem presented.

The original request, from the Company concerned, was for a transfer feed press which could handle the seven operations required for either washer or dryer tops. It was intended that dies should be changed whenever production was to be shifted from one product to the other. Under these conditions, runs would have to be relatively long and inventories would have to be maintained on both types of piece parts. Moreover, the die change-over process would have taken considerable time out of the production schedule. (It should be noted that moving bolsters had not been fully developed at this time).

The first suggested improvement involved a reconsideration of die design in order to utilise some of the dies for both piece parts. This would lessen the number of dies which had to be changed and therefore shorten down-time for change-over.

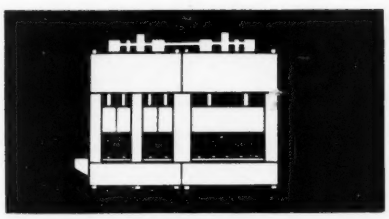
Our development engineers carried this a step further, and suggested a press which could hold all of the dies required for both piece parts, and in which change-over could be accomplished by slide adjustments. This would eliminate manual work involved in the change-over, and would shrink change-over time to minutes. In addition to the more obvious advantages of minimum labour cost and less down-time, this innovation made possible completely new thinking with regard to production scheduling. Now change-over could be more frequent and inventories kept at a very minimum. Production could be closely integrated with the assembly operation of the two appliances.

Putting both sets of dies in the press at the same time increased the size of the press from seven die stations to nine. It also created some problems of unbalanced loading. However, multiple slide arrangements were able to overcome this problem. The addition of several between-slide uprights further increased the size of the press.

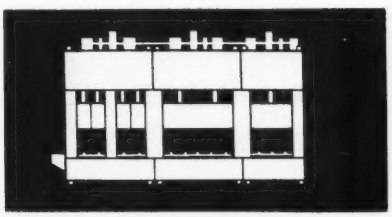
Split sides were then conceived to eliminate some of the extra uprights and reduce overall dimensions. Split slides are a pair of slides which operate between a single set of uprights, and guide against each other at the centre. The additional benefits of split sides — individual die adjustment and more satisfactory performance under conditions of unbalanced loading — also proved advantageous in the press.

As die design progressed further, need for additional electrically adjusted sub-slides for the latter operations proved necessary.

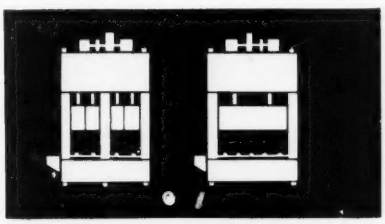
Even with the removal of several uprights through use of split sides, the press was still remarkably large. It now measures over 45′ left to right across the main frame structure. It is doubtful if a press of these dimensions could be constructed in a conventional manner. Certainly, shipment and erection in the customer's plant would have been difficult, if not



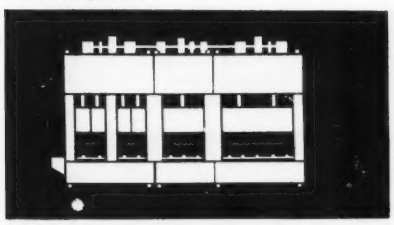
The GE press as it is now, producing washer and dryer tops in a dual tooling setup.



Additional modular units may be added to either end of the machine to increase the number of available stations, or . . .



As model changes modify production requirements the modular equipment may be separated into two presses, or . . .



Additional modular unit may be placed in the center to alter the sequence of tonnage capacities, etc.

Fig. 7(a). The press shown in Fig. 7 can be adapted in several ways to meet production or design changes.

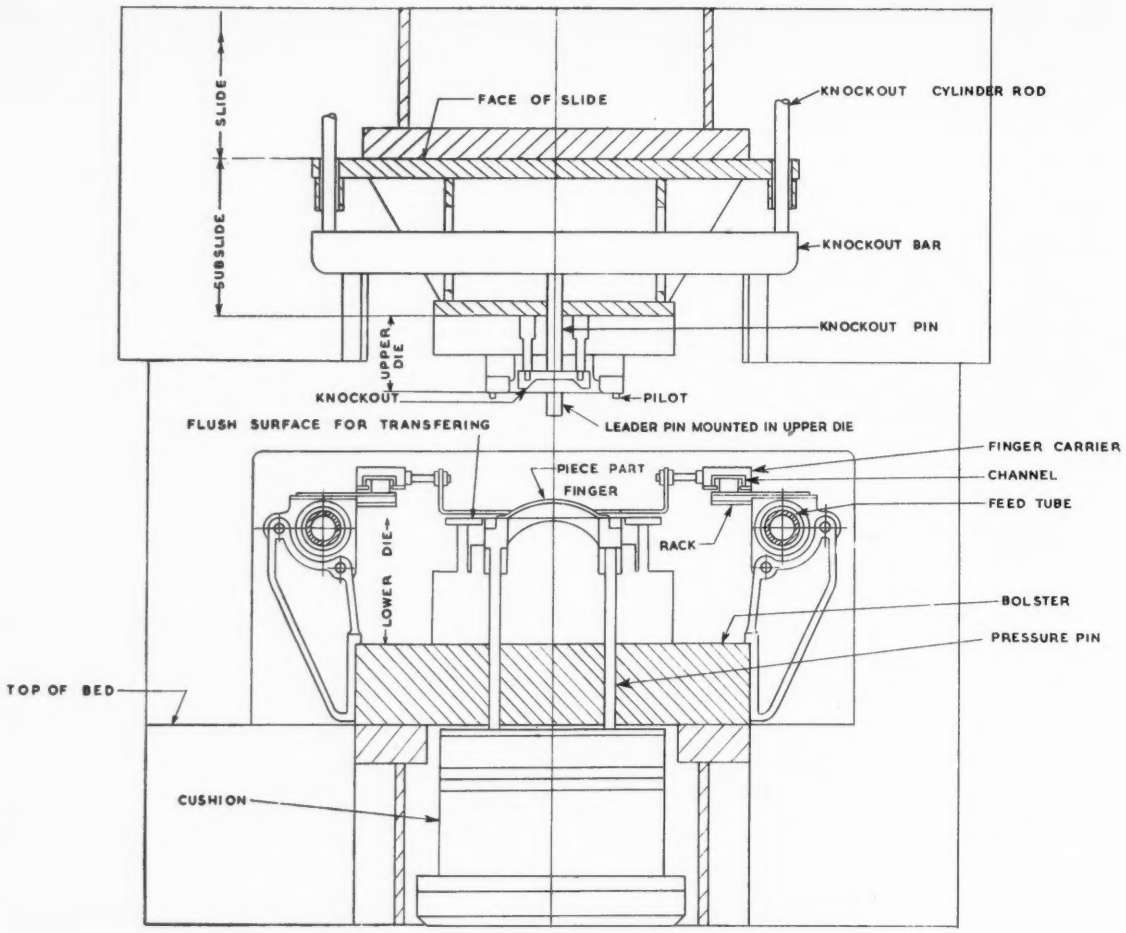


Fig. 8. Section through transfer station — press stroke up, fingers clamped.

prohibitive. Then, too, a structure of this size could be a monstrous white elephant if production requirements changed radically. Next year's production may require 10 die stations instead of nine. Even a press of this size might become too small.

Modular construction

So our Company developed the concept of modular construction. This particular press breaks down into two basic units, that is to say, two crowns and two beds are provided. These are joined together by a common "Siamese" upright which makes it all one structure. Separate drives are provided for each crown, but the two are mechanically coupled together.

In this way the press is practical to manufacture, easy to erect, and easy to ship. Now, if more die stations are needed in the future, the modular frame components can be taken apart, additional components added and the whole reassembled into a larger machine. Similarly, if the big machine is no longer required, the Siamese upright can be replaced with a couple of standard end uprights and the result will be two independent smaller presses.

This is highly integrated production at its best.

Fig. 8 gives an idea how transfer type dies must be built. Actually, they are essentially the same as conventional single action dies. Two basic changes are necessary: the part is always brought back to a common feed level with the cushions or springs, and the leader pins are always mounted in the top die shoe.

More cam dies are usually needed in transfer tooling than in conventional hand-fed operations, because the part is always kept in the same plane. These must be operated through deadmen to provide a free access for transfer fingers and part during transfer. It is essential that the transfer feed timing diagram be consulted for the press to make certain of transfer clearance for leader pins and cam posts. The press stroke should never be less than three times the maximum depth of part.

The drawing in Fig. 9 depicts Transflex automation for automotive type panels. It is equally adaptable to either bottom drive or top drive presses. The feed mechanism is overhead and is mechanically driven by cams, which are electrically synchronised. Air-operated jaw assemblies enter the dies to grip the part, in much the same manner as conventional unloading equipment, so that conventional dies can be used.

Transfer of the part is completely mechanical, so that positive control of the part is maintained at all times. It consists of lift, transfer and lower motions, This mechanism loads as well as unloads. Controls are provided so that a complete line can also be separated in two or three lines, each independent and completely automatic.

The manufacturers of small stampings have also been catered for and economical automation is available for them also. Fig. 10 shows a small "S" series Transflex press; this series is built from 75 tons to 300 tons and with right to left bed area from 60" to 120". This has all the essential features of the larger presses. Transfer feed stroke is adjustable from 8" to 16". The feed box is mounted overhead to conserve floor space and to make it possible for most presses of the series to be floor mounted, with resultant economy and high speed operation. We are currently building a press that will operate at 100 strokes per minute with an 8" feed stroke.

Our development activities have been engaged in work for the small producer in yet another way. Fig. 11 shows a Transflo feed mechanism, for the

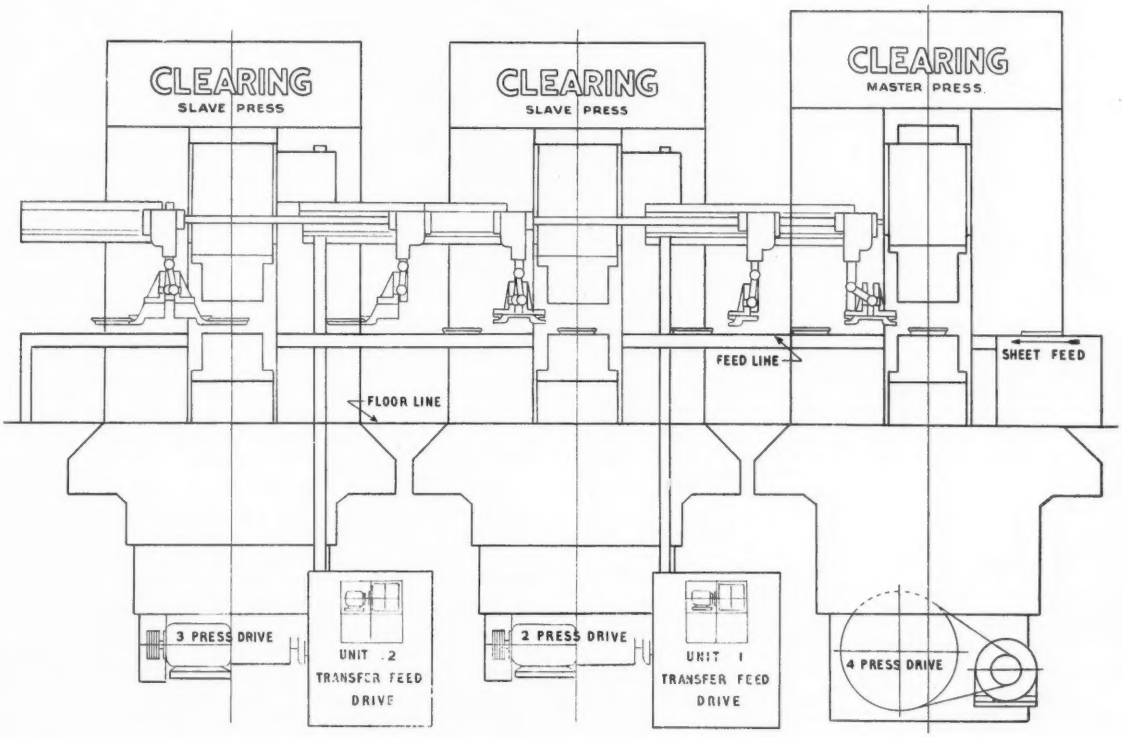


Fig. 9. Interpress transfer feed diagram.

Transfer feed unit 2
Carriage moved 2" of transfer stroke
Fingers clamped on part
Finger bar in raised position

Transfer feed unit 1
Carriage at beginning of transfer stroke
Finger bar in lowered position
Fingers ready to enter and clamp on part

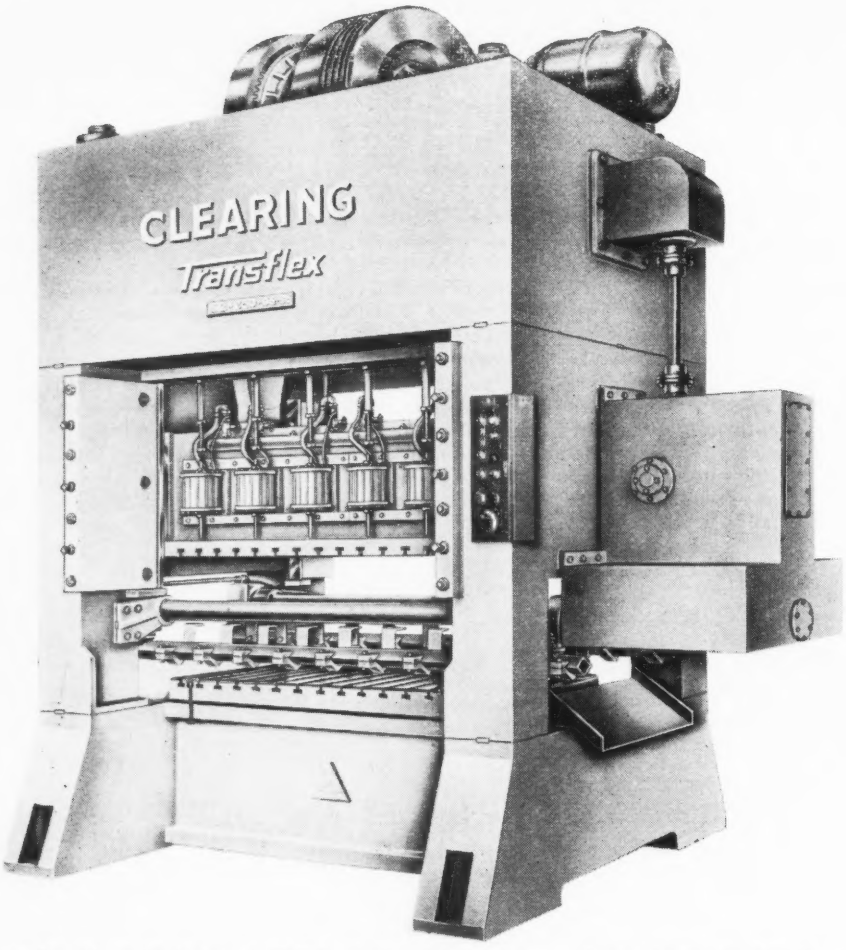


Fig. 10. Small "S" series Transflex press.

transfer of parts between O.B.I. presses or single point straight sides. The transfer motion consists of six stages :

1. clamp ;
2. lift ;
3. forward index ;
4. lower ;
5. unclamp ;
6. return index.

It is so designed that the lift and lower motions can be eliminated, and the height of lift and the length of the clamp stroke are adjustable. The mechanism for a complete line is actuated from a central power source. This feed makes it possible to convert a line of O.B.I. presses into essentially a transfer feed press. The feed operates continuously and cycle rates of the various elements are controlled by a welding type timer panel.

We are currently building a prototype. It is designed in module units, so that it will be possible, in the future, to deliver the feed from stock.

Fig. 12 shows an automated bottom drive press line equipped with moving bolsters. It also portrays an idea for new stamping plants. Modern stamping plants, built in the last decade, have utilised a complete lower level under the press room area. This has meant efficient scrap disposal, without interfering with the production process.

Our suggestion is that it is worth while to consider a third level in the stamping plant for die storage. This could be accomplished either in the manner shown in Fig 12, or by installing overhead platforms, between the presses, to form one completed and connected area for die storage above each press line. This is now possible because the dies are set at the sides of the press line with straight crane lifts, rather than between the presses. We thus get three basic levels for the stamping plant :

1. main floor — production ;
2. lower level — scrap disposal and maintenance ;
3. overhead — die storage.

When one considers the amount of area the stamping plant must reserve for the storage of dies, and compares the cost of this area with the cost of higher bays to accommodate the overhead storage, the idea we put forward merits the consideration of manufacturers planning new stamping plants. The idea is particularly appealing because of the consequent reduction in clutter in the production area.

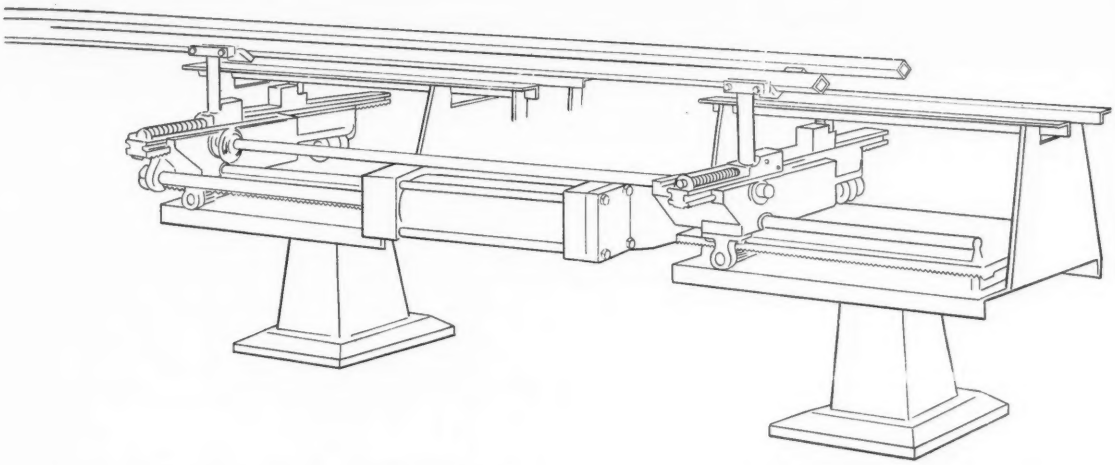


Fig. 11. Transflo feed mechanism, for the transfer of parts between O.B.I. presses or single point straight sides.

This is perhaps an appropriate point to emphasise that practical and flexible automation is not a product that can be purchased with "x" dollars, or pounds, but a concept that can be attained only by limitless ingenuity and boundless enthusiasm by both supplier and user.

What of the workers?

With the spreading use of automatic equipment, it became apparent that some public concern was being felt — and voiced — regarding the effect on the future of industrial workers. If these wonderful new machines could each do the work of several of the old type, and need only the minimum of attention, what would happen to the men displaced by such a development?

Time has shown that such anxieties were without any real foundation. It has become apparent in many companies that the introduction of the presses described, and other similar equipment, has so increased production, enabling the manufacturers to sell to a bigger market, that plants have had to be

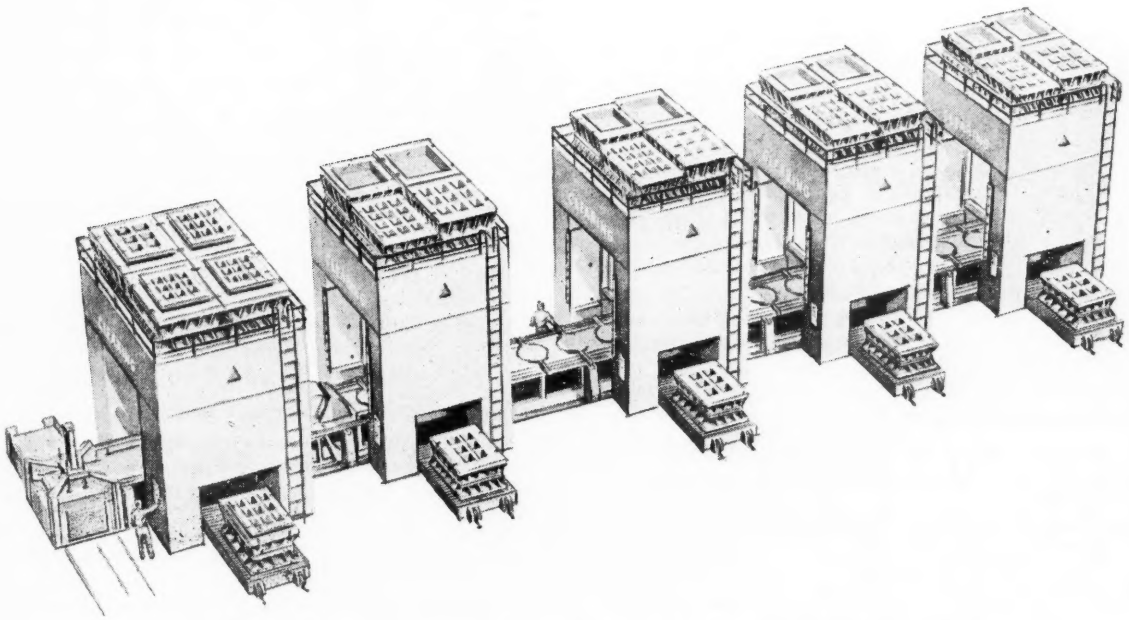


Fig. 12. Automated bottom drive press line equipped with moving bolsters.

enlarged to meet the subsequent bigger demands. Consequently, the men displaced initially have merely been transferred to other sections and processes.

Also, automatic equipment requires a greater level of skill in its operation, with the natural result that the industrial worker has been generally upgraded. It has been necessary to train more specialists, notably electricians, electrical engineers, hydraulic and mechanical engineers, and these men now enjoy a much higher status than they did previously, with correspondingly higher pay.

It is the hope of the manufacturers of this type of equipment that in time the drudgery will be taken out of many essential jobs, to make the tedious tasks more enjoyable and to enable the routine worker to derive more mental stimulation and satisfaction from his labours, as well as greater material rewards. It is also important to emphasise that the use of these automatic machines will inevitably improve the quality and so raise the standard of the products which reach the public.

It can truly be said, therefore, that the benefits of automation fall equally abundantly on employer, employee and consumer, and it is without doubt the responsibility of every one of us to see that the progress of automation is advanced in every way.

" WHAT ABOUT THE SMALL FIRM ? " —

concluded from page 626

Finally, the word " CONTROL " as this to some extent is associated with the word " CHANGE." As to control, it is necessary to have similar qualifications as referred to in relation to the word" CHANGE."

The best interpretation one would imagine for the word " Control " is " to guide and steer " like a competent helmsman of a ship, and not to assume that the interpretation of the word " Control " means to " Hamstring."

It is in this " Freedom " that the small firm can be very closely associated with Control, as he controls his own destiny and can quickly steer his ship in the direction of progress.

The control placed on the small firm is usually one of simple economics but because of the specialist knowledge, common sense and alertness, the small firm will move more quickly.

Well ! ! ! Now what about the small firm ? " Small " in employment, maybe, but " large " in importance.

In conclusion, one could rightly say that without the small firm automatic production would be in serious jeopardy, and let it be known that the small firm can and is using the technique of the production engineer both on batch and flow application to the benefit of the national economy.

It is sometimes said that we are thankful for small mercies, but let us in industry always be thankful for "Small Firms."

Acknowledgments

Appreciation is here recorded of assistance received from the following Companies in the preparation of this Paper:—

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Messrs. Picken & Son Ltd.
Messrs. Burnett & Lewis Ltd.
Coventry Chamber of Commerce.
European Productivity Agency.

" THE APPLICATION OF UNIT HEADS AND SPECIAL MACHINES AS AN AID TO BATCH PRODUCTION " — *concluded from page 662*

The foregoing is typical of the sort of arranging which can be done with unit machinery, as there is no reason why the same machines could not have been arranged to cater for additional similar parts which would have kept the line going full time.

It must be pointed out that in installing machines of unit construction, the Company is, in fact, purchasing production, not just for one component or even a series, but for many years ahead. For example, if a milling or drilling machine is purchased, they remain milling and drilling machines until the end of their span of life, whereas in a machine using unit heads, these can be arranged to perform practically all machining operations ; a head may commence its working life performing a milling operation, but at any time this can be changed to boring or drilling, etc.

This degree of flexibility which can be achieved by the ability to transfer heads from one operation to another, due to the use of standard elements in construction, allows machines to be rearranged very quickly to suit work of a different nature. Hence it is true to say that the Company is buying production capacity and not just a group of machines.

Unit machines are designed to meet the demand of all sizes of production—large, medium and small—and to arrive at the decision as to whether or not the unit machine is an economical proposition, the following facts must be borne in mind :-

1. Pay back should be approximately three years.
2. Improved cycle time is essential.
3. Improved accuracy is obtained, eliminating inspection as a separate operation.
4. Greater constancy is achieved by elimination of handling and stock parts.
5. Reclaimable parts are approximately 60% when component design changes.
6. Additional standard parts can be added to the present unit machine to include more operations.

THE APPLICATION OF UNIT HEADS AND SPECIAL MACHINES AS AN AID TO BATCH PRODUCTION

by G. H. ASBRIDGE.

Mr. Asbridge was educated at Worksop College and served an engineering apprenticeship with the Great Western Railway at Swindon from 1929/1931. *He subsequently held various positions with the Churchill Machine Tool Company, Manchester, until he joined the Army in* 1943, *and served as Captain in the R.E.M.E until* 1946.

On returning to the Churchill Machine Tool Company in 1946, *he was appointed Chief Designer, which position he held until* 1953, *when he joined Sentinel (Shrewsbury) Ltd., where he is now a Director.*

IT is not very long ago that the automotive industry were using conventional machine tools for the production of components which were required in large quantities. As, however, the need for greater production arose it gave birth to more and more specialised machines, which were designed around the manufacture of one particular component. The attendant advantages of this technique brought about a demand for still greater production and special machines.

These machines were in the beginning designed for each and every component, but this was a passing phase of comparatively short duration, as it soon became apparent that as more and more of the machines were built, a large degree of standardisation would be possible, and did develop, amongst the manufacturers of the machines at that time. This development has progressed to the extent that it is today possible to manufacture machines for special purposes, largely from standard basic components.

The experience gained in the use of specialised machine tools for large scale production can, we believe, be applied to the manufacture of components which are made only in relatively small quantities and may occur only at infrequent intervals.

Already there is available a wide range of standard machining units (Fig. 1) capable of performing, with the use of ancillary equipment, practically all machining operations and these are available for both mechanical and hydraulic operation. While these unit heads are essential to perform the physical machining operations, in themselves they are virtually useless without the complementary equipment that goes with them. For instance, it is necessary to have bases of differing sizes and widths on which to mount them, columns of varying heights for vertical mounting, multi-way centre beds (Figs. 2 and 3), all these components having common location and fixing points enabling an almost limitless number of combinations to be achieved.

" Off the peg " units

With all this equipment readily available and capable of being simply converted, with the addition of suitable holding fixtures, into very effective automatic machines, virtually " tailor-made " from " off the peg " units, it makes possible the use of this type of equipment on smaller component quantities (Fig. 4).

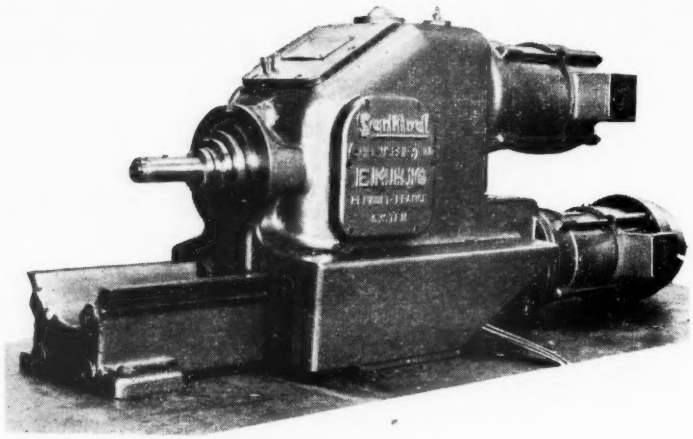

Fig. 1. Sentinel EMH 10 unit head of 1½ h.p. capacity.

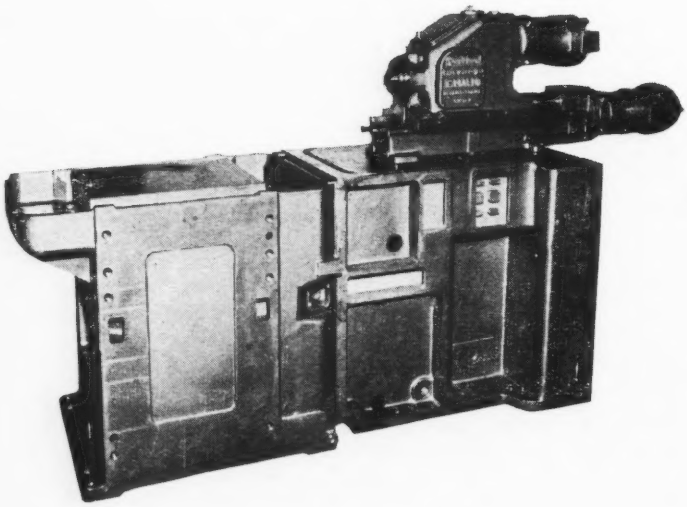

Fig. 2. Standard 3′ base and 3-way centre bed.

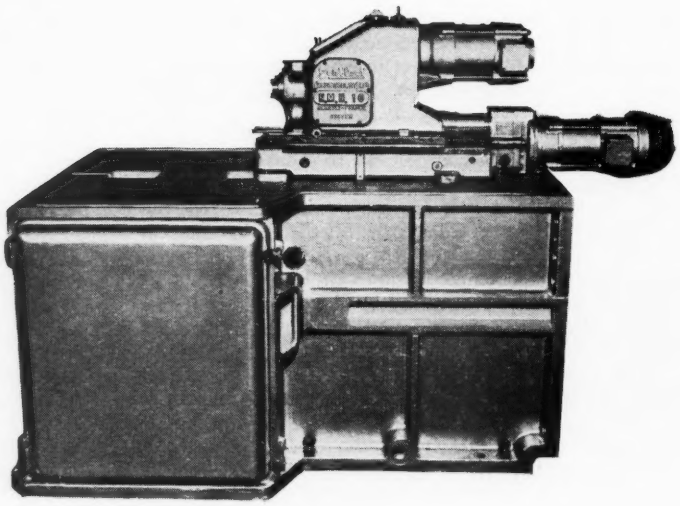

Fig. 3. EMH 10 unit head mounted on standard 5′ base.

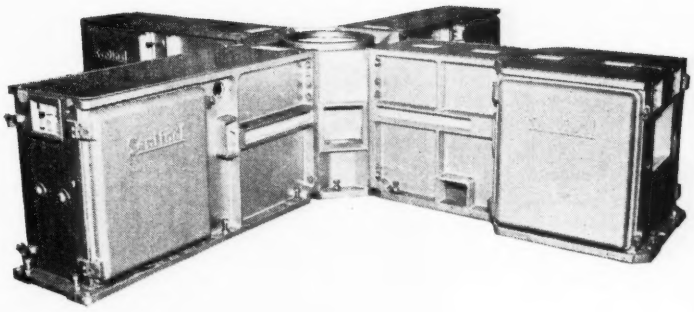

Fig. 4. Four-way drilling and tapping machine in course of construction — all components are standard parts.

There are many examples which could be quoted. In Fig. 5 is seen a machine for performing drilling, turning, boring and chamfering operations on induction manifolds, two at a time. Six different types of manifold are dealt with on this machine, the drilling remaining common. To change from one type to another it is only necessary to unclamp the platen type fixture and substitute another — air clamping makes this the work of a few moments only. Tool changing is equally simple, and it is only a matter of minutes before the machine is away again on another type of component. The complete machine was built with standard units.

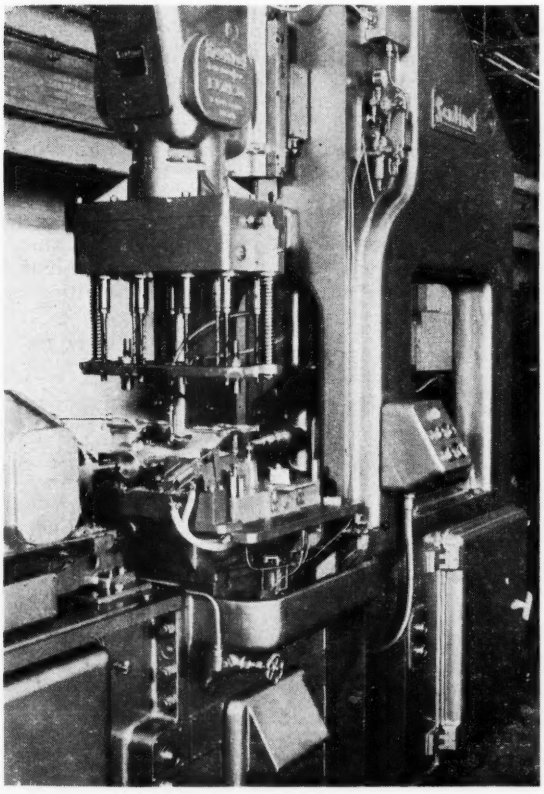

Fig. 5. Machining induction manifolds.

Fig. 6 shows another machine for the drilling of gudgeon pin holes — a wide range of pistons had to be covered. One basic fixture with interchangeable location spigots and adjustable clamps covered all types, and to give greater flexibility to the speed range, two speed gearboxes were introduced between the driving motors and unit heads.

This practice of building up special machines to deal with a wide range of similar components offers much more than just a machining unit, as other features can be built into the machine. It is well known that to adapt the majority of conventional machines to handle their own parts is a major operation. Fig. 7 shows in outline a machine for the drilling and tapping simultaneously of both ends of railway axles. Eventually it may have to cater for as many as ten different types from metre up to 5′ 6″ gauge, and up to a maximum weight of approximately 8 cwt. per axle. This machine will give many advantages, as apart from substantial increases in production due to the simultaneous nature of operations, it has built into it its own handling devices, which for components of this nature are of incalculable worth, as a great deal of productive time can be lost by waiting for cranes.

Importance of component design

It will be apparent, from the few foregoing examples, that the machine tool designer using interchangeable standard machining and constructive units can produce machines, automatic in their operation, and incorporating loading and unloading devices, and if necessary the checking of components after any operation, similar to those used in the mass production of components and yet flexible enough to be easily changed from one component to another similar one, in the minimum of time and without excessive tool changes. This much the designer can do; how much more could not be achieved if more thought was given to the component design, so that differences between similar components were kept to a minimum and common features kept to a maximum?

Even greater advantages can be obtained from this type of equipment, although component quantities

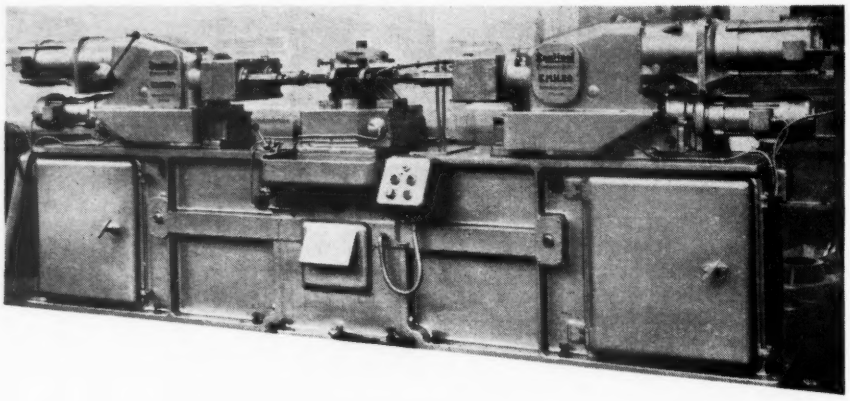

Fig. 6. Gudgeon pin drilling machine.

need not be large, if instead of one machine fitting into a sequence of conventional machines, a series of simple machines is built to deal complete with the component.

A recent study was made of a component which necessitated fourteen operations, mainly drilling, tapping, boring, milling, each operation requiring a change from one fixture to another and being performed on conventional machines. The same component dealt with entirely on unit machines would have given the following comparisons :-

Number of machines reduced from 11 to 8.
Number of operations reduced from 11 to 6.
Floor space occupied reduced from 356 to 215 sq. ft.
The floor/floor time reduced from 42 to 19 min.

Another advantage which would have been gained lay in the use of only one type of fixture, as once the component was loaded into the fixture it passed through the whole sequence of operations without removal. The number of fixtures required would have been about twelve, but twelve similar ones are easier to manufacture and maintain than fourteen different ones. Errors due to removal and replacement on fixtures are non-existent, resulting in more consistent components and furthermore there is no stock between machines. The machines were virtually a hand-operated transfer system.

The one criticism which was levelled against this arrangement was that it was too quick, but I do not believe that this is a valid point. The conventional machines being used were satisfactory for the present production but were working at almost maximum output, and should an increased production have been required, additional machines would have had to be installed. The unit machines were able to produce twice the output, with fewer operators and floor space, and even though this was not required the possibility remains for greater capacity, and certain "schools of thought" have proved that to work unit machines part-time at least releases more other machines for vital work and shows a considerable saving over the year. It is, of course, true that on the conventional machines other work could be done between batches, but when the time taken to break down and re-set is taken into account, it is very unlikely to be a paying proposition, particularly when the risk of scrap in re-setting is also considered.

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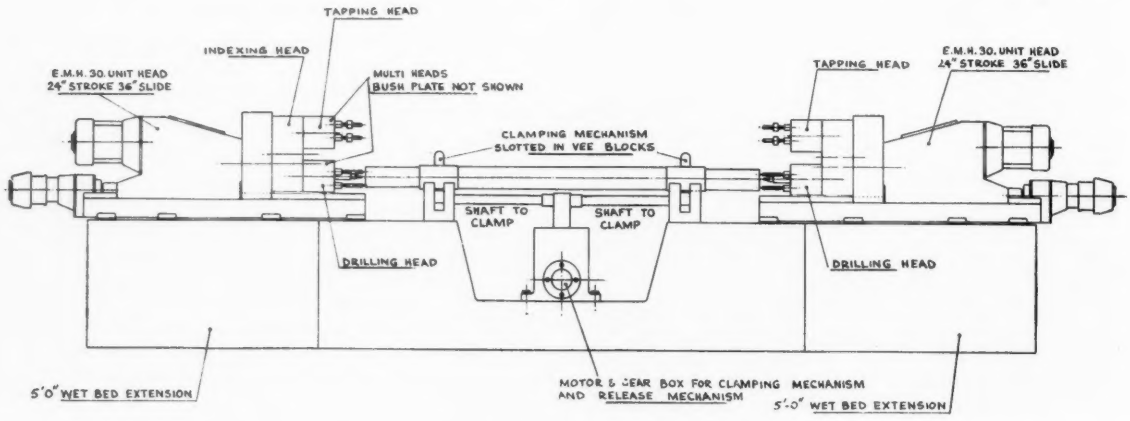

Fig. 7. Axle drilling and tapping machine with built-in handling equipment.

WORKING TOGETHER WITH OTHER MEN

by Professor A. F. BURSTALL,

D.Sc., Ph.D., M.I.Mech.E.

Presented to the Newcastle upon Tyne Section of the Institution, 18th February, 1957

Professor Burstall was educated at King Edward VI Grammar School, Birmingham, and at the Universities of Birmingham and Cambridge. At Birmingham University he obtained the degrees of B.Sc. with First Class Honours in Mechanical Engineering, and later M.Sc., and at the University of Cambridge he was one of the first research students in engineering to obtain a Ph.D. degree of that University in 1925.

His first appointment was with Synthetic Ammonia and Nitrates Ltd. (later merged into I.C.I. Ltd.) as research engineer, assistant chief engineer, and works engineer at their Billingham Factory, which he left in 1934 *to become Technical Advisor to the Board of the Aluminium Plant and Vessel Co. Ltd. in London. In* 1937 *he was appointed Professor of Engineering and Dean of the Faculty of Engineering at the University of Melbourne, Australia, where he developed mechanical respirators for infantile paralysis; gas producers for motor vehicles; and built new workshops at the University.*

During the War he was employed in the Armament Design Department of the Ministry of Supply in Britain, and in 1945 *was appointed to his present position as Professor of Mechanical Engineering at King's College, Newcastle upon Tyne, in the University of Durham.*

Professor Burstall is a Member of the Institution of Mechanical Engineers, and a Fellow of the Institute of Industrial Administration. He was a Founder Member both of the Australian Institute of Management, and of the British Institute of Management.

PROFESSORS of Engineering are supposed to know something about training engineers to do their professional work, but only seldom is it mentioned that the engineers they train may be required to work together with one another. When it is mentioned, one usually hears a reference to cricket and football as being the best ways of training people, whether engineers or others, in how to work together. I don't believe it.

In this Paper I propose to examine this question as I have found it in my own experience, and I will endeavour to throw some enlightenment upon my own observations by reference to comments that I have heard or read upon this subject.

The ability to work harmoniously with others is one of the most precious attributes that a man or woman can possess. Few things can be more destructive of the productivity of a working team than lack of harmony. The subject seems to me to be of supreme importance, and yet we hesitate to speak of it — except in terms of the playing fields of Eton.

Men engaged in controlling the work of others — as engineers so often are — are well aware of the importance of the personal attitudes of those they control — e.g. Mr. J. G. Bulger, who recently read a Paper (1) entitled "The New Factory" to the Institution of Mechanical Engineers in London wrote that

> "all employed must sink any personal feelings,
> "jealousies or bias, in favour of the satisfactory
> "conclusion of the project". (1)

Another industrialist, Mr. D. L. Wattleworth, General Manager of the Workington Steelworks, speaking recently in Carlisle on Industrial Relations, placed first among the supervisor's tasks the problem of creating harmony between people at work. An

explanation of the cause of industrial disharmony has been offered by Mr. Nigel Balchin, the novelist, who writes (2) :-

"The existence of an incentive problem is a "measure of our failure to make productive work "the direct source of happiness rather than the "indirect means by which a man buys it. The "acceptance of this idea means that industry has "to try to discover what people want from life; "this is a difficult task in which the people in "question cannot help much, since they them-"selves do not know very clearly. Human beings "are motivated by a large number of instincts; any "sales or publicity expert knows this and uses the "knowledge in his work on the public. Yet, when "the public is inside the factory the knowledge is "completely ignored. Industry's behaviour towards "its workpeople has changed considerably in the "last 100 years, but its understanding of them has "hardly changed at all. Now the need to know "what motivates people is urgent, but it takes too "long to find out; the scientist is once more being "asked to repair years of neglect in five minutes. "Scientists must be honest and say it cannot be "done; they must not be persuaded to introduce "fundamentally unimportant measures tacked on "to the main structure in an attempt to obtain "quick results. They must study people and what "they do and make their results known to industry; "they must adjust industry to life, not life to "industry. Psychologists must stop trying to "manage factories for managements and con-"centrate on giving management some knowledge "of the human beings who are their problem" (2).

Part of the satisfaction that many people get from their work comes from associating while at work with congenial companions. The young housewife feels lonely and dissatisfied because she has been deprived of companionship during working hours that she had become accustomed to at school and office, shop or factory. Twenty-five years ago I myself rejected the idea of becoming a poultry farmer, because it would have offered less companionship than engineering and that of a less congenial kind.

A dispassionate approach

Some people regard all such problems as the sole province of the psychologist, others have faith that their religion will give them guidance in how to handle all questions involving morals and ethics, as these do. My own endeavour is to approach the matter dispassionately and impersonally to see how one may consciously and deliberately promote a co-operative attitude among the people with whom one works. This leads me to ask "What is the inducement to co-operation among a group of men who are working together?". Among professional engineers there is seldom a direct financial reward for creating harmony, though there may sometimes be an indirect financial penalty for creating discord. The primary inducement to work together is usually a belief that the job in hand is more important than what any individual will get out of it. Sometimes this is expressed by saying that the job is more important than the individual. James D. Mooney begins his book (3) on the "Principles of Organisation" with the simplest illustration of two men uniting their strength to move some object that is too heavy or too bulky to be moved by one. Here we have associated effort with a common purpose, the first principle that underlies all industrial organisation. I think it was Spengler (4) in his "Man and Technics" who suggested that the original object of speech was for the purpose of men working together to carry out an act in accordance with intention, time, place and means. He thought that the difficulty of conveying one's meaning to, and imposing one's will on, another, produced the technique of grammar and sentences, the correct modes of ordering, questioning and answering, on the basis of practical and not theoretical intentions and purposes. Theoretical reflectiveness probably played no part in the beginnings of speech which was of a practical nature and proceeded from what Spengler called "the thought of the hand". The example serves to remind us that when two individuals co-operate for a common purpose each expects the other to do his best, and I would suggest that there is a moral obligation on each, not only to do his best, but also to appear to be doing his best, so that each may be spurred on by the spectacle of the strivings of his companion. Perhaps this inducement to co-operate has been better expressed by Mr. K. G. Collier in his recent book (5) "The Science of Humanity", when he writes :

"The ideal man or woman must have not only an "allegiance to the civilised values of honesty, "loyalty, respect for other people and so on, but "a realisation that duties come before rights, that "whatever anyone else does, you yourself are "under an obligation to your community to make "a solid contribution of hard work and service for "the common good." (5)

He continues :

"The recognition that you yourself are bound by a "universal moral law entails a clear and willing "recognition of your own responsibility and, if "necessary, guilt." (5)

The question whether you can be ready to accept guilt or a sense that you have sinned without a religious sanction for the moral law, he does not discuss.

I suggest that some of you may all unconsciously hold out another inducement to your fellows to co-operate with you. "It's a real pleasure to work with that man!" "He is always cheerful and good tempered, sometimes he fairly bubbles over with good humour; even when he is a bit subdued he makes a joke of his disappointments. But it is not only cheerfulness with him — he is tactful too. He seems to be extraordinarily sensitive to the feelings of other people and able to bury his own personal dislikes and avoid differences with the people he works with." Compare this with the individual most of us know who takes a pride in provoking disputes and quarrels among his fellows. Such men are to be compared with a native aborigine who comes the first time into a big city from his native reserve, and takes delight in bunting passers-by on the pavement because

he has never learned to walk on a pavement and unconsciously avoid the people that he passes. Mentally, some of us are still at the stage of the savage. "Let's start something!"

Another way to provoke one's fellows to unco-operativeness is to send messages, memoranda, or letters couched in varying degrees of rudeness, when the proper thing to do is to arrange a face-to-face discussion. This situation most often arises when something has gone wrong or when somebody thinks that something is going to go wrong. It is discussed with deep understanding by Mary Parker Follett in her essay "Constructive Conflict", and others that have been collected together under the title "Dynamic Administration" (6).

Incidents like these may lead to lengthy enquiries or "inquests" which may be necessary for fact-finding in extreme cases, but they can easily do more harm than good by spreading blame or a sense of time wasted and frustration.

The withholding of information

Probably the commonest form of unco-operativeness is by withholding information. In almost any group of men you will find someone who practises it to a greater or less degree. Its popularity is due to the power it gives to those who withhold information over those from whom the information is withheld. I recall an example during the War, when cables were sent to America from the Ministry office where I worked for technical reports that were later found to be locked up in the desk of the man in the next office to our own.

Another inducement to co-operation is an obvious willingness to be helpful to the other members of the team. Perhaps a willingness to accept help is an inducement too, for there must be both give and take for satisfying co-operation. No one likes to be accepting help all the time without giving something in return. It should be noted that the harmony of a group working together can be destroyed by the unco-operativeness of a single individual.

When a group of men is called upon to work together and to think together, there is always an unsolved problem whose existence must be accepted in good faith by all. Nothing is more discouraging than finding that there is within the group someone who persistently refuses to believe in the job that has to be done. Moreover, it is a first requirement that all who collaborate should be prepared to modify and change their ideas as a result of working together. The man with fixed ideas who thinks that by changing his mind, he loses face, is a great handicap to those who have to try to work with him — in fact, it can almost be said that he can only work alone.

The ethics of changing one's mind is a question that has arisen several times in my professional experience, and its discussion has been most time-consuming. On one occasion a technical committee had to be persuaded to change the decision of a previous meeting because new evidence had come to light shewing that the earlier decision was wrong. At the time it was made it had appeared to be the right one but it was based on insufficient premises. Some members of the group were loth to alter the decision, because by doing so, it would be disclosed that their judgment on the first occasion had been wrong. Most committees have less conscience about changing decisions, presumably because they have no sense of guilt for errors of judgment in which they shared. This is one of the reasons why I prefer to have a single individual as Managing Director or chief executive, rather than a board of management. The single individual has a conscience and feels his responsibility in exercising his judgment and making decisions. The very fact that he is less willing to change his mind makes for greater security to all that he controls. The following quotation from Hazlitt's Table-talk (7), published in 1821, shows that these ideas are by no means new. This comment is attributed to Sir Edward Cooke, who is reputed to have made it in the year 1612 about the administration of Sutton's Hospital:

'Corporate Bodies have no Soul'

"Corporate bodies are more corrupt and profligate
"than individuals, because they have more power
"to do mischief, and are less amenable to disgrace
"or punishment. They feel neither shame, remorse,
"gratitude, nor good-will. The principle of private
"or natural conscience is extinguished in each
"individual (we have no moral sense in the breasts
"of others) and nothing is considered but how the
"united efforts of the whole (released from idle
"scruples) may be best directed to the obtaining of
"political advantages and privileges to be shared
"as common spoil." (7)

The 'spectator attitude'

On the other hand, one can sometimes regard putting people to work together as a means of getting them to change their minds. There is, however, the danger that the mildly unco-operative member may take the attitude of a spectator and enjoy the interplay of ideas without taking an active part. This attitude is discussed by E. H. Schell, Professor of Business Management at the M.I.T., in his book "The Technique of Executive Control" (8). He points out that the spectator attitude also appeals because one's chances of making mistakes are thereby reduced. It means less hard work. Thinking together with one's equals should be a hard and exhausting activity, and when it is well done it never conduces to personal pride. Professor Schell writes:

"After an active discussion you may lament a
"number of early suggestions which later required
"amendment and even rejection. You may recall
"statements which you wish you had not made.
"You may think how much better it would have
"been if you had withheld your ideas until the
"others had shot their bolt, so that you could have
"the benefit of their point of view before
"expressing yours. This sort of speculation is fruit-
"less and beside the point. The prime question

"which you should be able to answer in "the affirmative is 'Did I *help* with the "thinking ?'" (8)

Elsewhere the same author remarks (9) that:

"Group collaboration that does not involve real "intellectual toil is an unwarrantable waste of "time" (9).

The ability to work with one another is, for the most part, a social ability. Social ability has been investigated in regard to salesmen, both for choosing them and for devising the best ways of training them. Oakley in his book "Men at Work" (10) asserts that both formal and informal tuition have considerable influence in improving the social ability of the individual. So, incidentally, does capacity and willingness for self-criticism, for much of what we learn about how to handle other people comes from the analysis of our reactions to the ways in which they handle us. Mental alertness — "quickness of uptake" — plays an important part in bringing about this realisation and those who are too dull or too indifferent to give heed to such matters are often astonishingly stupid in their social relations.

It seems to me that rather too many technical engineers are given to an apparently superior attitude about the importance of themselves and their work, which leads them to disregard the sensibilities and feelings of other people, with the result that resentment and ill-feeling are engendered.

Subsequently there are delays, explanations, recriminations, apologies, which all take up time that need never have been so spent if the parties had approached each other in the first place with the circumspection and respect that is the due of every human soul. In my observation salesmen, medical men and lawyers are all better able to deal with one another than are technical engineers and scientists.

A man's guiding and satisfying idea of himself is what Jung calls his 'persona'. Originally it meant the mask worn by an actor in the Greek or Roman drama. It gave his character, it was what he thought he was.

H. G. Wells elaborated this idea in his book "The Work, Wealth and Happiness of Mankind" (11). Professor Henry Clay in his "Economics for the General Reader" (12) put Jung's conception into economic terms:

"A man's willingness to work is studied in relation "to his 'standard of life', his conception of what "is due to him and his proper scale and quality of "living. But his persona brings in more than this; "his sense of obligation; of what it is graceful and "becoming to do; his pride; what is honourable "or insulting for him, and a vast motivating com-"plex over and above the standard of life" (12).

It is only for their dealings with one another that I take my fellow engineers to task. Those concerned with getting craftsmen and mechanics and other tradesmen to work usually behave in their relations with their men as if they were quite alive to such principles as "the resistance to change", "the inevitability of gradualness" and the importance of "face saving", or more poetically:

"Men must be taught as if you taught them not "And things unknown proposed as things forgot."

I suggest that these principles would not be out of place in negotiations between many of our professional colleagues. Each of them is a living sentient being with his own peculiarly intense perceptions of his own particular rights and his own particular wrongs. If you doubt what I am saying, have a talk to some draughtsmen who have worked in the same drawing office for the last five years.

Group activity

I come now to that form of group activity that is supposed to take place in committee rooms, Let me quote first from one of its strongest advocates, Mr. Ordway Tead, who, in his book entitled "Human Nature and Management" (13) subjects the technique of group action to a close and appraising scrutiny.

"A group" he says, "is an organisation of minds "and the new ideas evolved by group thinking are "more than the sum of the individual ideas which "might have been offered by the same persons "sitting alone and preparing memoranda of pro-"posals on the matter in hand."

"All experience shows that the stimulus, fertilisa-"tion, criticism and suggestion of group participa-"tion in the thinking process produces a new idea, "a creative contribution, which will be distinctly "superior in practical value to ideas evolved in "any other way. Not only that, but the process of "reaching the idea is such that, in a unique way, it "becomes quickly and thoroughly a part of the "working motives and active influences in the "mental life of those who have been a party to "reaching it. Thought and action are welded more "closely than they are when the thinking activity "is isolated and subjective" (13).

Mr. Tead also regards group thinking and group action in committees as a valuable means whereby the executive or leader of a team can, to a greater or lesser degree, *share his experience* with the other members of the committee. He also sets out the requisite conditions for successful committee work and suggests a normal limit of 15 persons in the group.

"which is as large as is usually desirable unless "there is a remarkably skilful chairman who can "keep as many as 20 people really involved in the "discussion. A dozen people or less is ordinarily "the most effective number" (13)

My personal preference is for six or seven as the optimum number of members to serve on a working committee, and I should like to see any that have more than nine members broken up into smaller units so that all the members could have a reasonable share in discussion. In these remarks I am excluding large Councils and Boards of 20 to 100 members or more. They are like small parliaments where the principal functions of the members are to vote and to exercise their right to be heard. Group thinking and group action are of necessity delegated to a small cabinet or sub-committee where each member can have the opportunity to *help* in the thinking.

The optimum duration of a meeting depends upon the capacity of its members to sustain close attention and real thinking over a period. Here I agree with Mr. Tead that no session should be allowed to continue for more than an hour-and-a-half, because that represents the limit of time for most people. Longer is possible if the individuals know one another well, for it is very much easier to comprehend what is being said by an old friend than it is to listen to a stranger.

Surely this is because friends say what we want to hear. Compare the pleasure of listening to what you want to hear with the irritation of having to listen to what you don't want to hear. The first is an exhilarating experience; the other, depressing.

I think that the prevailing popularity of committees as a means of working together calls for the general recognition of some rules of behaviour. In the first place, when people are appointed or elected to a committee, they are apt to feel that there is a moral obligation either to attend the meetings or to resign. Resigning from committees is distasteful to most people and so the ones who feel the obligation tend to attend the meetings, whether they are interested in the business or not. They don't want to miss anything! Accordingly, it is a common occurrence to have a large meeting in which only a handful of members take part in the discussion. The result is extremely wasteful of both time and money. Had the silent members taken the trouble to read the papers for the meeting — which they could do far more quickly than by attending — they could have saved themselves the time, trouble and distraction that attendance usually entails. The effort to remain silent is sometimes too much for those who are not interested in the business and so they speak of matters that are not before the meeting, or cunningly introduce them as if they were. Thus they justify their attendance, for few experienced committee men can come from a session of silence and say "I have earned my pay this afternoon, what a good thing that I came!".

There are nearly always some members of a committee who cannot resist the temptation to intervene occasionally to make some humourous remark which they think is clever, and many a chairman has used the ensuing laughter as a device to dispose of the issue and pass on to the next business. In my view, members who indulge in levity at serious meetings should be severely censured by their colleagues for what is, after all, irresponsible behaviour. Usually they are applauded for the amusement they provide, and so it is not surprising that one finds committee men who look upon their attendance at meetings as primarily a source of entertainment, and if the interest flags they will deliberately try to start something!

There are times, too, when destructive criticism is carried too far, when it becomes merely an act of levity and ill-will. Often it seems to be a manifestation of the resistance to change — a common trait of human nature.

These comments serve to illustrate the wide gap that exists between what acutally happens on most committees that I have known and Ordway Tead's ideal of a committee as "an organisation of minds". I doubt whether any improvement is taking place, and when one considers the growth of the committee system throughout our lifetimes, the present prospect is almost frightening. Probably millions of man hours are spent each year on committee work, in this country alone. Surely there is a case for a conscious, deliberate effort being made to improve its practice!

Oliver Sheldon, writing on the use and abuse of committees in a compilation entitled "Factory Organisation" (14), regards committees as expensive in time: he says:

> "They tend to sap individual responsibility; they often involve delays, and are apt to obscure issues and to arrange compromises where clear-cut decisions are necessary. To effect co-ordination does not mean in every case that a committee must be established. Committees should be a last resource rather than a first thought. If they seem the only alternative, it behoves one to consider whether the need does not arise from a shortage of common co-ordination, from faults in the planning of the organisation, or from lack of standard procedures. All these are fertilisers of the 'committee habit'. The haphazard setting up of a new committee" says Sheldon, "is equivalent to the haphazard appointment of a new official" (14).

Sheldon considers that:

> "Much of the need for the discussion which arises on committees can be eliminated by the determination and publication of standard procedures for the execution of various types of work, particularly that in which several different departments may be involved" (14).

Importance of common doctrine

A common doctrine is essential for constructive thinking. It might be worth while for working committees when first appointed to spend some time in stating their common doctrine. Perhaps those who cannot subscribe to it should resign rather than submit "minority reports".

In his book (15) "The Philosophy of Management" Sheldon distinguishes four kinds of committees, executive — which must, of course, have some officer to carry through and supervise the execution of its decisions — advisory — to some official who is in need of advice; educative — to keep staff regularly notified of events and policies; and lastly, co-ordinative, to ensure that the work of individuals in different spheres is in harmony with the plan for the whole organisation.

The quality of the secretariat and the character of the chairman have the greatest influence on the success or failure of committee work (it may be one reason for the comparative success of most meetings of engineers on purely technical subjects). This was brought home to me 15 years ago, in Melbourne, where for three years I was part-time Commissioner of the Victorian State Electricity Undertaking, A

small group of four, with a Secretary and Executive Officer in attendance, we met weekly to discuss and decide questions which had been prepared for decision beforehand in papers circulated prior to the meeting. We had a mutual regard and respect for one another, and particularly for our chairman, who would never take a vote, but would always integrate our views so as to obtain a unanimous decision. If this was not forthcoming, he would postpone the matter for further discussion and ultimately unanimity was secured. It was Mary Follett who pointed out in "Constructive Conflict" the superiority of integration over domination or compromise, both of which only postpone the real solution of a dispute.

"We can set conflict to work and make it *do* "something for us", she wrote. "We may wish "to abolish conflict, but we cannot get rid of "diversity. We must face life as it is, and under- "stand that diversity is its most essential feature ". . . Fear of difference is dread of life itself. "It is possible to conceive conflict as not "necessarily a wasteful outbreak of incompati- "bilities, but a *normal* process by which socially "valuable differences register themselves for the "enrichment of all concerned"(6).

To see these principles put into practice at weekly meetings was the crowning satisfaction in my experience of management and administration. We used to have what I will call "harmonious conflicts", from which we arose at the end of the meeting feeling that we had all shared in the achievement of something that was important and valuable for the future.

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RESEARCH PUBLICATIONS

The Institution is advised by PERA that Dr. G. Schlesinger's book on "Accuracy in Machine Tools: How to Measure and Maintain It" is now out of print and cannot, therefore, be supplied. The following I.Prod.E. publications are, however, still obtainable from PERA at "Staveley Lodge", Melton Mowbray, Leicestershire.

"Practical Drilling Tests" by D. F. Galloway and I. S. Morton. Price 21s.

"Machine Tool Research and Development" by D. F. Galloway. Price 10s. 6d.

It is also announced that the following PERA research reports are generally released to the public, and may be obtained from Melton Mowbray at the prices stated:

"Packaging of Engineering Equipment." Price 10s.6d.

"Packaging of Engineering Equipment." Price 10s. 6d.

"Hi-Jet System of Cutting Oil Application." Price 7s. 6d.

"Notes on Selection and Use of Soluble Cutting Oils." Price 10s. 6d.

"Drilling Titanium Alloy Ti 150A" (Press reprint). Free.

news of members

Mr. W. J. Edgington, Member, has temporarily left Great Britain for a business tour in the West Indies. He is Chairman of the Institution's Doncaster Section.

Mr. F. A. Gardiner, Member, has taken up an appointment with Mains Radio Gramophones Ltd., Bradford, Yorkshire, as Chief Production Engineer.

Mr. R. Parish, Member, has recently taken up an appointment in Singapore with Messrs. Guthrie & Co. Ltd., as Pan-Malayan Engineering Manager. He will be in charge of all the Company's engineering activities in Singapore, throughout Malaya and Borneo.

Mr. L. S. Pitteway, Member, is now Divisional General Works Manager, Taylor, Taylor & Hobson Ltd., Leicester.

Mr. V. N. Agarwala, Associate Member, has relinquished his appointment of Q.P. Assistant Superintendent of Development; Technical Development Establishment, Electronics, Bangalore, Government of India, and has taken up the appointment of Deputy General Manager, Barakar Engineering and Foundry Works Limited, Nirshachatti (Dhanbad), Bihar.

Mr. J. Barrett, Associate Member, has relinquished his appointment with Harrison McGregor & Guest Ltd., Leigh, Lancashire, and has now taken up a position as Development Engineer, Agricultural Division, Thomas Green & Sons Ltd., Leeds.

Mr. D. J. Billau, Associate Member, has obtained leave of absence from his position as Lecturer in Production Engineering at the College of Technology at Wolverhampton, to enable him to accept an appointment as Design Engineer with Messrs. Ericksen Tool Company, Cleveland, Ohio, U.S.A.

Mr. G. W. Butler, Associate Member, has relinquished his position of Assistant Lecturer in Production Engineering at the County Technical College, Wednesbury, and has taken up an appointment as Lecturer in Production Engineering at the Wolverhampton and Staffordshire College of Technology.

Mr. A. W. J. Chisholm, Associate Member, has recently taken up the position of Head of the Department of Mechanical Engineering at the Royal Technical College, Salford.

Dr. S. Eilon, Associate Member, will be away temporarily from the Imperial College of Science and Technology, during the next academic year, as he has been appointed an Associate Professor in the Mechanical Engineering Department at the Israel Institute of Technology, in Haifa.

Mr. John G. Elting, Associate Member, has relinquished his position as Technical Production Liaison Engineer with Ultra Electric Ltd., and has now taken up the appointment of Works Manager with Messrs. Simon Equipment Ltd.

Mr. John R. Leighton, Associate Member, General Manager of Prince-Smith and Stells Ltd., Keighley, has been appointed to the Board. He joined the Company in 1930.

Mr. M. G. Page, Associate Member, has relinquished his position of Senior Lecturer (Production Engineering) at South East London Technical College, to take up the appointment of Head of the Department of Production Engineering and Management at Wolverhampton and Staffordshire College of Technology.

Mr. S. S. Palit, Associate Member, Industrial Development Officer, D.V.C., has recently been appointed Specialist (Small Scale Industries) under UNESCO Technical Assistance Mission in Iraq for development of small scale industries.

Mr. J. W. L. Russell, Associate Member, has recently been promoted from Assistant Works Manager to Works Manager, National Carbon Co. (India) Ltd., Camperdown Works, Calcutta.

Mr. R. F. Cox, Associate, has relinquished his appointment as Chief Technician to Arthur Balfour & Co., Sheffield, and has joined Ex-Cell-O Corporation (Machine Tools) Ltd., Leicester, as Midland Area Technical Representative.

Mr. R. N. Hoard, Associate, has relinquished his appointment as Assistant Lecturer in charge of Mathematics at Keighley Technical College, and has been appointed Deputy Headmaster, Mundella Grammar School, Nottingham.

Mr. P. J. Atkinson, Graduate, is now a Grade I Engineer with the Snowy Mountains Hydro-Electric Authority, Cooma North, New South Wales.

Mr. D. C. Bear, Graduate, has relinquished his appointment as Production Manager of the Charles Street Works of the Iso-Speedic Co. Ltd., Warwick, and has taken up the position of General Manager of Hughes (Taplow) Ltd., West Drayton.

Mr. Edwin W. Batchelor, Graduate, has been transferred from the Mead Works, Washington, of Kaiser Aluminium & Chemical Corporation, to Ravenswood, West Virginia. Mr. Batchelor is a Mechanical Engineer.

Mr. M. Calderbank, Graduate, has been appointed an Assistant Lecturer, Grade 'B', at the Bolton Technical College.

Mr. Raymond B. Dwarte, Graduate, has relinquished his position with the Jeep Manufacturing Division of Messrs. Mahindra & Mahindra Ltd., Bombay, and is now Assistant to the Chief Engineer (Production and Development) at Durham-Bush (Canada) Ltd., Toronto, Ontario, Canada.

Mr. E. V. L. Hughes, Graduate, has now left the B.S.A. Research Department, Small Heath, Birmingham, in order to take up an appointment as Design Section Leader on fuel systems with Rover Gas Turbines Ltd., Solihull.

Mr. D. F. R. Jepp, Graduate, is now with Thomas Mercer (Airgauges) Ltd., Redburn, Hertfordshire, as Chief Draughtsman.

Mr. D. Laxton, Graduate, has relinquished his appointment as a Jig and Tool Draughtsman with The British United Shoe Machinery Co. Ltd., Leicester. He is now an Assistant Lecturer at the Isle of Ely College of Further Education and Horticultural Institute, Wisbech, Cambridgeshire.

Mr. R. D. Saha, Graduate, has recently joined the University of Minnesota, as a Teaching Assistant in the Department of Industrial Engineering.

Mr. P. T. Sylvester, Graduate, has now taken up an appointment as an Assistant Engineer in the National Coal Board Central Engineering Establishment at Stanhope Bretby, near Burton-on-Trent.

APPOINTMENT OF ASSISTANT EDUCATION AND TECHNICAL OFFICER

Mr. Ian King, G.I.Mech.E., Grad.I.Prod.E., has been appointed the Institution's Assistant Education and Technical Officer. Mr. King was educated at Hampton Grammar School and subsequently served his engineering apprenticeship with the Ministry of Supply, at the R.S.A. Factory, at Enfield. After completing his National Service with the R.A.F., he joined the Computer Division of the Decca Radar Company, as a mechanical and production design engineer, where he remained until joining the staff of the Institution on 1st September last.

The Late Mr. J. W. Berry, M.I.Prod.E.

THERE are some members whose devoted service to the Institution behind the scenes does not appear with great prominence to the general body of the membership. Without such men, prepared to give considerable time and trouble to tasks often of drudgery, the Institution could not properly fulfil its avowed function. Mr. J. W. Berry, whose recent death was such a shock to his associates, was one of these.

At the time of joining the Institution in its very early days, he was associated with Dr. Fisher, then Principal of the Wolverhampton Technical College, in there creating one of the earliest courses in Production Engineering. He became a founder member of the Institution's Education and Research Committee (as it then was) and later its Chairman, a position he held for very many years. During his long period in this office he was able to see and guide the growth of production engineering education from microscopic beginnings to a nation-wide movement, and to take a prominent part in the negotiations which, in the early days of the Second World War, led to the establishment of the Higher National Certificate in Production Engineering. For a number of years he served on the Joint Committee — representing this Institution, the Institution of Mechanical Engineers and the Ministry of Education — which operates this scheme.

The routine and somewhat irksome work necessary to the operation of the Institution's own examinations is conducted by a little-known body — the Joint Examination Board. Mr. Berry was responsible for the creation of this and was a member to the day of his death. His 25 years' Chairmanship of the Board was recognised a year ago when the members thereof presented him with an inscribed silver cigarette box — a gift which he greatly valued.

The Birmingham Section, of whose Committee Mr. Berry was for some years a member, showed their appreciation of his work by electing him to the position of Section President, an office he filled with distinction. For many years, too, he served as a Member of Council.

A production engineer of great practical ability, Mr. Berry was Managing Director of the Birmingham Aluminium Casting Company Ltd.

The Institution is the poorer for his passing.

J.F.

REVIEW

* *Industry and Technical Progress.* C. F. Carter and B. R. Williams. Pp. viii + 244. (London: Oxford University Press, 1957.) 25s. net.

THE series of post-war inquisitions into British industrial technology has been bedevilled by three groups of mischief-makers. First, the group which W. S. Gilbert had in mind when he wrote:

> "There's the idiot who praises with enthusiastic tone
> All centuries but this and every country but his own."

Secondly, those who for political reasons maintain that everything done by private capital is poorly conceived and badly executed or perfectly conceived and brilliantly executed. Thirdly, those who insist on discussing the subject without any qualifications to do so, with the result that the problem is seen out of perspective and the conclusions are ill-balanced.

The Council of the British Association, meeting in Belfast in 1952, decided to appoint a committee "to study the problem of speeding up in industry the application of the results of scientific research". The committee's first instructions were to prepare a programme of work, and the first half of 1953 was spent in a preliminary survey of the problem. This convinced the committee that substantial new investigations would be needed, and it decided to look both for additional sponsors of the work and for extra funds.

Some months of negotiation followed, as a result of which the Royal Society of Arts and the Nuffield Foundation agreed to join the British Association in sponsoring the investigation. The interest of the Royal Society of Arts is shown by its full title, The Royal Society for the Encouragement of Arts, Manufactures and Commerce, while the Nuffield Foundation has within the ample scope of its trust deed "the advancement of social well-being". The reconstituted committee, with representatives of all three sponsors, met for the first time in April, 1954.

The British Association committee was able to bequeath to its successor an agreement by the Board of Trade to supply funds for research under the Conditional Aid scheme; and these funds were later augmented by the Department of Scientific and Industrial Research, under the same scheme, to make the total sum available about £20,000.

The committee's field of work is defined by the following terms of reference:

> "To identify those factors which determine, in different industries and in different types of firm, the speed of application of new scientific and technical knowledge; to examine their relative importance, their inter-relation, and their correlation with characteristics of the firm or industry; to obtain evidence of the effectiveness of measures already taken to speed up the application of science in industry, or to remove hindrances to such application; and to examine the possible results of other proposed measures."

At the beginning of 1955 these were extended, as a consequence of an invitation from the Treasury and an offer of additional funds, to include "factors influencing innovation" and "the collection, in the course of the case studies, of material which would contribute to knowledge of the background of investment decisions".

One result of this very powerful and well supported enquiry is a book, *Industry and Technical Progress*, written by C. F. Carter and B. R. Williams on behalf of the Science and Industry Committee. Other reports are expected to follow.

To one who, like myself, lives from year to year in the centre of the complex of problems which the Science and Industry Committee has set itself to study, it is a positive pleasure to read so well conceived and well balanced an account of its opinions. The authors take an early opportunity of commenting on the enquiries of others, which "yielded some impressive examples of the enthusiasm of the British for disparaging their own country."

There is only one way to form an assessment of the performance of a whole nation in technical matters, and that is to see their achievements against the background of the national culture pattern as a whole.

When we have decided the price we are prepared to pay for not having to lead the American way of life; when we have decided the price we must of necessity pay for having pioneered everything in the last century and for the out-dated basic equipment with which we are saddled in consequence; *then* we can start comparing our practice with American practice.

When we have similarly decided the price we are prepared to pay for being the world's most powerful block of 50 million people with global responsibilities

far in excess of our numerical strength, then we can start comparing our capital programme with that of a small neutralist nation such as the Swiss.

"Discussions on technical progressiveness tend to speak with a fine generality of 'the American', 'the German' or 'the British' manufacturer, illustrating their judgments with examples from particular trades. The judgments may be correct but they are in no way proved correct by the examples. Every country has backward industries; to find all industries equally progressive would be as odd as finding that all the pupils in a school form were 'equal first'. There is no ground for supposing the same industries to be progressive in different countries. Therefore, it must be expected at all times that there will be some British industries which are technically behind their American counterparts, and there is no difficulty in finding some which are in advance. We early decided that at all costs we would be sparing in generalisations about British industry."

There speaks an economist, an economist who goes straight on to point out that one man's meat may be another man's poison. Industrial efficiency must mean efficiency directed to cost reduction. It cannot be assessed except in terms of local costs. A country where land is dear and labour cheap ought *not* to model itself on one where land is cheap and labour dear. After considering the background in this way, basic research is considered next, and the conclusion reached is that "the evidence . . . is not sufficient to support a simple assertion that British basic and applied science is being frustrated by the conservatism of the British business man. The facts appear to us to be more complex."

Exactly how complex the facts are then appears from an analysis which follows over several chapters dealing with communicating the results of research, the extent of research activity, research development as a management technique, the readiness to use the overflow and the decision to commit resources. These are all excellent descriptions of the fine-grained mosaic factors which constitute the subject matter of the problem and should be studied carefully by anyone interested in understanding them.

A disquisition on "Trained Men and Women" follows. This is a difficult field of enquiry. It is difficult to compare educational standards between nation and nation; difficult to form a realistic assessment of our own needs (a firm's estimates always ignore the consequences of satisfying their competitors' requirements equally with their own and the maintained demand resulting); difficult to credit the low productivity that appears to be implied by the high production of technologists in Russia; and difficult to make allowances for rapid contemporary changes.

With one statement made I must join issue. It relates to the relative snob-values of degrees in different disciplines and takes the form that "the laboratory chemist looks down on the engineer". This legendary belief arose by the circulation in high places of a sociological thesis, the handiwork of a theorist who asserted it without a shadow of evidence. As rumours grow, it grew; and everybody now believes it because everybody now believes it.

If any laboratory chemist, on reading this article, decides that he does in fact look down on engineers, I would be greatly obliged if he would write and tell me so. The same invitation is open to any engineer who can produce evidence that he has at any time been looked down on by a laboratory chemist. Until one or the other can give me the slightest grounds for believing this allegation to be true, I shall continue to maintain that it is a rumour having no more foundation than that we all stick up for our own profession, no matter which!

Whatever the exact shortage may be, it is indisputable that scientists and technologists are in short supply. Whether there is a shortage of money to finance and encourage development is more controversial.

"Every Board of Directors in the country might feel that, given a tax remission, they would spend more on research. Yet if the true limiting factor were a shortage of scientists, the tax remission might achieve no net result whatever in the encouragement of research. It is difficult to remember that what seems obviously possible to one firm — which can always hope to attract scientists from its competitors — may be quite impossible if all firms are taken together."

As to capital for commercialisation: " . . . the evidence is that recently there has not been much difference between the U.S.A. and U.K. rates of investment relative to National Product. The U.K. has made room for an exceptionally high rate of investment in plant, machinery and housing by running down its capital equipment in the form of commercial buildings, roads and railways, and the programme is therefore somewhat unbalanced; but to suggest that it is discreditably small is hardly fair. Of course, if people had saved more, industry could have got on faster still, and with much less trouble from inflation; yet much has been achieved."

The report is not, in spite of its cautious optimism, a panegyric. Faults in industry are readily ascertainable and are dealt with objectively. They are, however, seen always in correct perspective, as components in a mosaic, as individual factors not to be assessed in general terms outside the particular context of each occurrence.

Only one generally negative conclusion emerges and it is to the following effect:

> "Backwardness is self perpetuating both in firms and industries; the backward firm, even if it can be made to desire technical progress, is ill placed to command the resources (and, in particular, the human ability) necessary to begin that progress. It will take much ingenuity by industry and government to break up the crust of habit and to divert lively and able minds from the places where change is most likely to those where it is most needed."

That is, in very truth, the kernel of the problem.

HALSBURY

Reprinted from the J. Roy Inst. Chem. 1957, 81, 413.

ADDITIONS

Amison, W. T. **"Introduction to Stud Welding."** *Richmond, Surrey, Association of Engineering and Shipbuilding Draughtsmen,* 1957. 55 *pages. Illustrated. Diagrams.* 3s.
An elementary account of the process written for the design or methods engineer who wants to know its capabilities and limitations.

British Electrical Development Association, London. **"Induction and Dielectric Heating."** *London, the Association,* 1957. 191 *pages. Illustrated. Diagrams.* (Electricity and Productivity Series No. 6.)) 8s. 6d.
The book attempts to demonstrate the essential simplicity of induction and dielectric heating and to show how and where these methods of heating can be used. It is not written for the specialist electrical engineer. Part 1 describes the induction heating of metals; Part 2, induction heating for metallurgical purposes; and Part 3, dielectric heating. Part 2 includes chapters on surface hardening, "through" heating, annealing, brazing, soldering and welding Part 3 has chapters on dielectric heating for plastics and woodworking.

British Institute of Management, London. **"Measurement of Work in the Office."** *London, the Institute,* 1956. 20 *pages.* (Office Management Series No. 2.) 4s.
A much needed introduction to a subject about which little has been written. Some of the basic methods of work measurement are described, and their application to clerical operations indicated. The report was produced under the guidance of a committee consisting of representatives of the British Institute of Management, The Institute of Cost and Works Accountants, and the Office Management Association.

British Standards Institution, London, **"Annual Report, 1956 - 1957."** *London, the Institution,* 1957. 272 *pages.* 7s. 6d.

Burton, Malcolm S. **"Applied Metallurgy for Engineers."** *New York, etc., McGraw-Hill,* 1956. 407 *pages. Illustrated. Diagrams.* 56s. 6d.
Describes the metallurgical bases of metalworking processes such as welding, casting, cold working processes, and powder metallurgy processes. The book attempts to provide the metallurgical knowledge necessary for the selection of a process for an application.

Cherry, J. **"American Teaching and Practice of Industrial Engineering and Management."** *Cranfield, College of Aeronautics,* 1956. 138 *pages. Illustrated.* (CoA note 39).
Reports the findings of a mission which visited the United States of America to "observe and gain experience of American methods of training in industrial engineering and management, both in universities and industrial plants". The mission visited a representative cross-section of American industrial plants and educational establishments, attended conferences on industrial engineering, and took part in courses. This report deals mainly with industrial engineering. Before describing and discussing American educational methods, the author discusses the definition of "industrial engineering", and the function and status of the American industrial engineer. Appendices give examples of curricula at universities and colleges of Great Britain and the United States. The report states that education in industrial engineering in the United States lays emphasis on the need for sound education in the basic engineering sciences, prior to the study of industrial engineering subjects; and that the value of formal education in industrial engineering is acknowledged by most industrialists. Comparison between Great Britain and the United States reveals the inadequacy of the Higher National Certificate Courses in Production Engineering; and a plea is made for more encouragement to students to take the Higher National Diploma courses. The mission comprised: Mr. T. B. Worth, of Birmingham College of Advanced Technology; Mr. K. J. Shone, of the Royal Technical College, Glasgow; Dr. D. M. Williams; and the author.

Delgarmo, E. Paul. **"Materials and Processes in Manufacturing."** *New York, Macmillan,* 1957. 755 *pages. Illustrated. Diagrams.* 52s.
A college textbook for engineering students. Part 1 describes engineering materials (i.e. metals and plastics) and their treatment. Other parts describe the casting and forming processes; the machining processes; the welding and allied processes; ancillary processes and techniques, such as planning and layout; and surface finish treatment. The material is presented from the point of view of the manufacture. For instance, in Part 1, sufficient metallurgical information is given to explain how and why a certain material is used for a particular application. Similarly enough information is given about machine tools to show what they can do and how they do it. There are questions at the end of each chapter.

European Productivity Agency, Paris. **"International Guide to Sources of Technical Information: France."** *Paris, the Agency,* 1955. 61 *pages.*
Lists research organisations and other sources of technical information in France.

Friedmann, Georges. **"Industrial Society: the Emergence of the Human Problems of Automation." ("Problemes Humains du Mechinisme Industriel.")** Edited and with an introduction by Harold L. Sheppard. *Glencoe, Illinois, The Free Press,* 1955. 436 *pages.* 50s.
The first (French) edition of this book was published in 1947. Some notes and other material have been added to the American edition. For nearly 30 years the author has been studying the increasing effects of technology on the personality of the worker. Part 1 of this book is a critical examination of the Taylorism; Part 2 begins with an analysis of the problems of monotony, and with a study of the influence of assembly line work and "automation" on the worker. A study of the development of occupational skills is illustrated by examples from specific industries. Finally, in Part 2, the author suggests a broader and more humanistic basis for the training of apprentices and other young workers. Part 3 is a detailed study of workers' reaction to "rationalisation", and a survey of research in industrial relations, in which comparisons are made between the well-known "Hawthorne investigations" of the Western Electric Company, and studies made at the Bata Shoe firm in Czechoslovakia and at two French firms, in which attempts were made to improve worker-management relationship. The author attempts in conclusion to describe conditions in which human work would be revitalised, while the greatest benefits were obtained from technological progress. Much of the interest of the work for British readers lies in its description of French work in human relations, and its description of conditions in France and other parts of the Continent.

Grant, Eugene L. **"Principles of Engineering Economy."** 3rd edition. *New York, Ronald Press,* 1950. 623 *pages.* 75s.
". . . the fundamental objective has been to explain the technique of answering the "Will it pay?" question in engineering situations . . ."

Lamble, J. H. **"The Mechanical Testing and Inspection of Engineering Materials."** *London, Cleaver-Hume Press,* 1956. *Pages* 459 - 498. *Diagrams.* 3s. 6d.
Reprint of Chapter XX of "Modern Workshop Technology", Part 1, 2nd edition, 1956. Edited by H. Wright-Baker.

Latil, Pierre de. **"Thinking by Machines: a Study of Cybernetics."** Translated from the French by Y. M. Goilla. *London, Sidgwick and Jackson,* 1956. 353 *pages. Illustrated. Diagrams.* 45s.
A popular, but scientific and comprehensive account of the new science of cybernetics, which includes an account of the work of the English scientists Grey Walter and W. R. Ashby. The chapter on synthetic animals includes an amusing account of the behaviour of Grey Walter's "tortoise" Elsie. First published in French under the title "La Pensee Artificielle", in 1953.

"The Making of an Administrator." Edited by A. Dunshire. *Manchester, Manchester University Press, for the Royal Institute of Public Administration,* 1956. 124 *pages.* 10s. 6d.
Reprints of lectures delivered to commemorate the centenary of the Northcote-Trevelyan report on the organisation of the civil service. The book is therefore, primarily, though not exclusively concerned with administration in the public services. Contents: Bridges, Sir Edward — Administration: what is it? and how can it be learnt?; Clarke, D. K. — Educating the administrator (describes the Administrative Staff College); Urwick, L. D. — Management and the administrator; Barwell, Sir Harold — The Administrator in local government; Self, Sir Henry — The responsibility of the administrator; Dunshire, A. — Comment (summing up).

National Institute of Industrial Psychology, London. **"Training Factory Workers."** A report on a survey of the training of semi-skilled and unskilled workers in the United Kingdom, carried out under Project 179 of the European Productivity Agency, by the National Institute of Industrial Psychology. *London, Staples Press,* 1956. 127 *pages.*

Owen, D. G. **"Computers and Steel."** *London, British Iron and Steel Research Association,* 1957. 24 *pages. Illustrated. Diagrams.*
In 1956, B.I.S.R.A. decided to establish a computer applications section within the Association's Operational Research Department. The Association has on order a Ferranti "Pegasus" computer which will be used for solving some of the scientific problems met with in the Association's technical research, and for demonstrating the commercial applications of computers that are possible in the iron and steel industry. Some suggested uses are outlined in this pamphlet.

PEP (Political and Economic Planning), London. **"Three Case Studies in Automation."** *London, PEP,* 1957. 58 *pages. Illustrated. Diagrams.* 7s. 6d.
"The aim was to obtain close comparisons of methods and operations before and after the introduction of automatic techniques, in order to bring out the technical, economic and managerial consequences of automation and the problems to which it gave rise." The three case studies are: "The manufacture of bearing tube; a case study of advanced mechanisation in the engineering industry"; "The Stanlow platformer: a case study in automatic process control"; "The Leo computer: a case study in the use of an electronic computer in routine clerical work." The case studies were presented at the Institution's National Conference at Harrogate, 1957.

Parkinson, A. C. **"A First Year Engineering Drawing: Covering the First Year National Certificate Course in Mechanical Engineering."** 5th edition. *London, Pitman,* 1957. 182 *pages. Diagrams.* 9s.

Das Refa Buch. **"Band 5: Der Kalkulatorische Verfahrenvergleich Insbesondere Die Wirtschaftlichkeitsrechnung",** von Prof. Dr. Ing. habil. Dr. J. Withoff. *Munich, Carl Hanser Verlag,* 1956. 182 *pages.* 17.80 DM.
Reports the work of a REFA Committee on costing.

Scientific Film Association, London. **"Films and Automation."** *London, the Association,* 1957. 24 *pages.* 3s. 6d.
An annotated list of films on automation and related subjects, obtainable from film libraries, industrial firms and other sources.

Summer, W. **"Photosensitors: a Treatise on Photo-Electric Devices and their Application to Industry."** *London, Chapman and Hall,* 1957. 675 *pages. Illustrated. Diagrams.* 105s.
The word "photosensitors" denotes all those devices which respond to the action of light. Part 1 of this book describes the characteristics of photosensitors, their associated circuits and optical equipment. Part 2 describes their applications. Those of particular interest to production engineers include: protective devices in machinery; production control; assembly control; inspection; counting devices.

Stroer, H. J. **"Mehr Technik — mehr. Ingenieure: der Mangel an Maschinenbau-Ingenieuren — Ursache — Umfang — Abhilfe."** *Frankfurt, Maschinenbau-Verlag,* 1957. 77 *pages. Diagrams. Appendix. Zahlentafeln.* 44 *pages.*
Deals with the shortage of mechanical engineers, and suggests causes and remedies. The appendix gives statistics of engineers in industrial and government service and of students at engineering schools. Comparative statistics are given for European countries and the U.S.A.

Tin Research Institute, Greenford, Middlesex. **"Tinplate Handbook: Facts about Tinplate for Buyers and Users."** 3rd edition. *Greenford, Middlesex, the Institute,* 1956. 44 *pages. Illustrated. Diagrams.*

Van Santen, G. W. **"Introduction to the Study of Mechanical Vibration."** Translated from the Dutch by G. Ducloux. *Eindhoven, Holland, Philips Technical Library,* 1953. 296 *pages. Diagrams.* 35s.
A translation and revision of the 1st Dutch edition which was published in 1950. The author, who is a member of the industrial control and measuring apparatus department of Philips Industries Ltd., reviews the elementary theory of vibrations and some of the problems of vibration met with in practice (e.g. wheel-wobble in motor-cars and aircraft; vibration of high-tension cables in the wind). The principles of equipment for vibration measurement, vibration measuring instruments, and hints on vibration measurement, are dealt with in successive chapters, and a final chapter deals briefly with "human vibration measuring apparatus", e.g. the ear.

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Five unique lingual glossaries from English, French, German, Italian and Spanish. Prepared by the Z.D.A. for the European Pressure Die Casting Committee.

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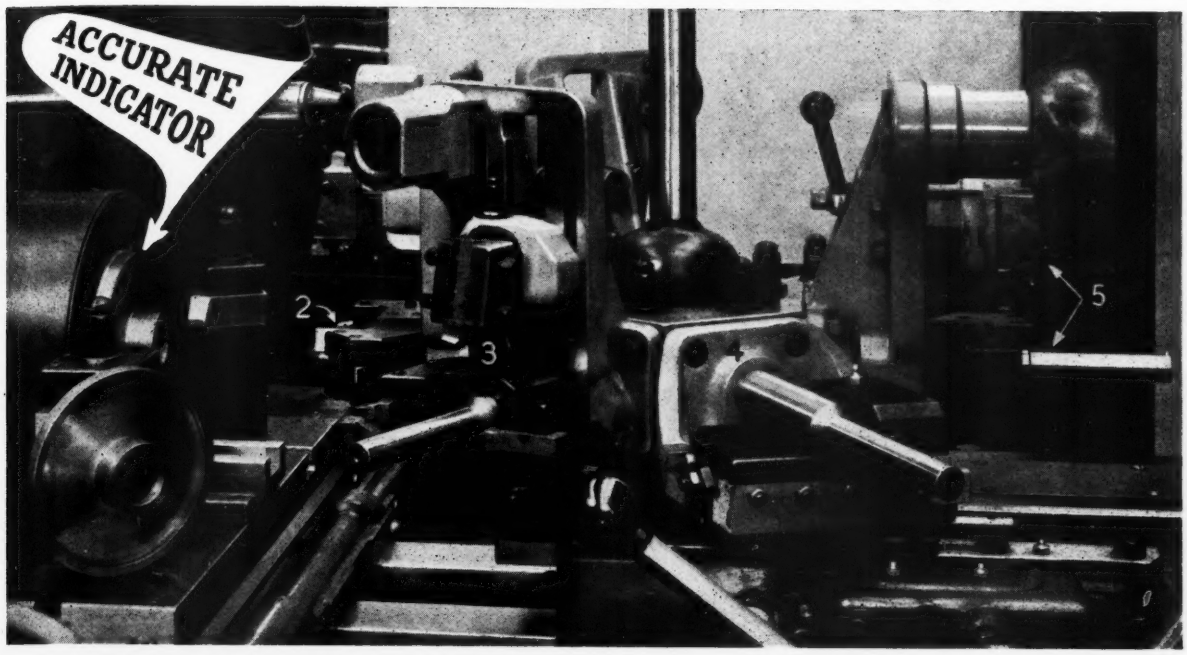

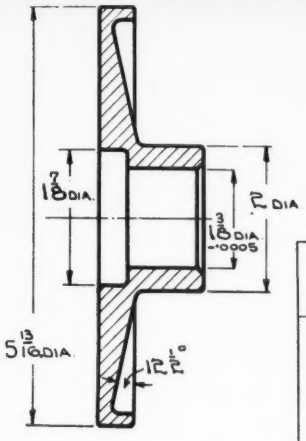

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FITTED WITH 200 mm. 3-JAW AIR CHUCK

DESCRIPTION OF OPERATION	Tool Position		Spindle Speed R.P.M.	Surface Speed Ft. per Min.	Feed Cuts per inch
	Hex. Turret	Cross-slide			
1. Chuck on o/dia.	—	—			
2. Double Face	—	Rear	260	405	Hand
3. Rough Bore 1⅜", Turn 2" and 5 1/16" dia.	1	—	260	405	125
4. Bore inside Rim and Radius Boss	2	—	358	515	125
5. Turn Boss and Angle Face (2 cuts)	3	Centre	358	515	128
6. Finish Turn o/dia. Face & Chamfer Boss	4	—	358	545	125
7. Reverse Component in Chuck Jaws	—	—			
8. Bore 1⅞" and 1⅜" dias.	5	—	260	405	125
Rough and Finish Face	—	Front			128
9. Microbore 1⅜" dia.	6	—	954	343	125
10. Remove.	—	—			

Floor-to-Floor Time: 6 mins. each

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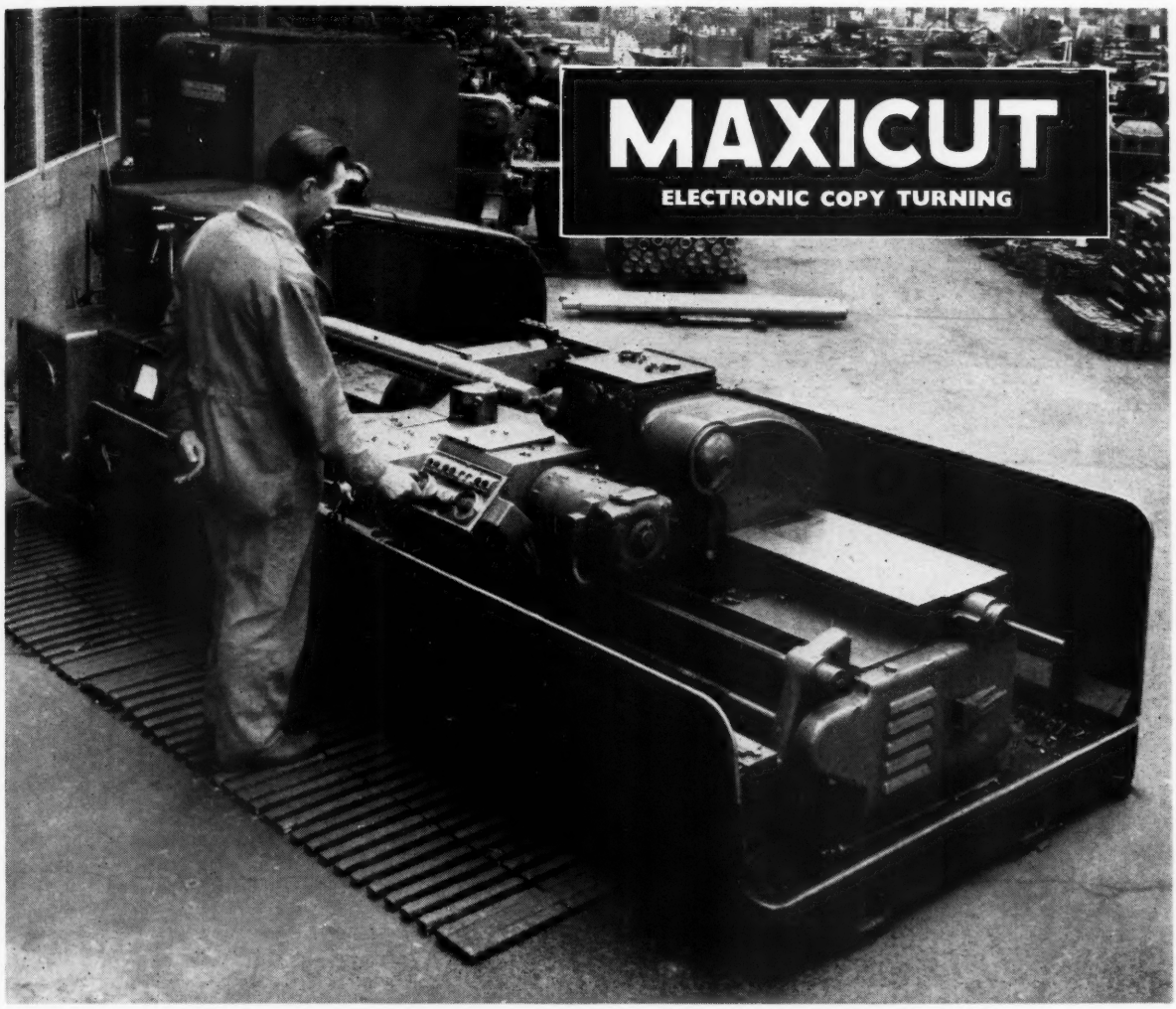

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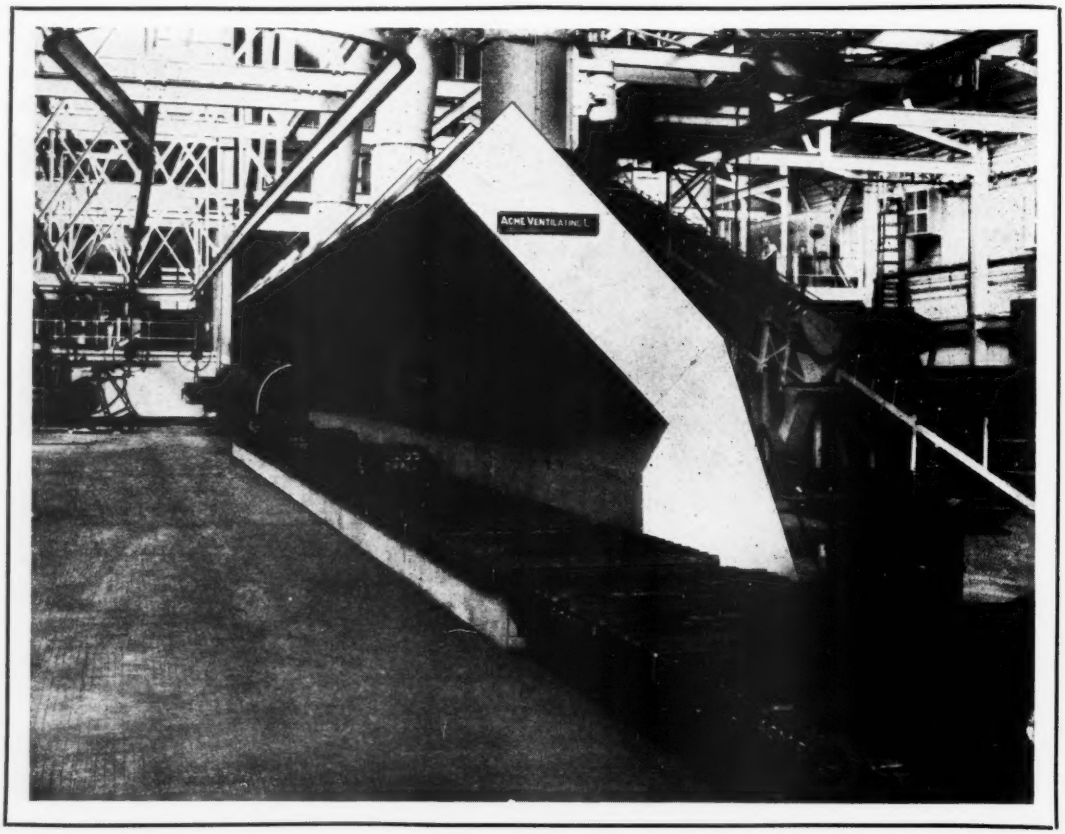

This is a photograph of a typical Acme Installation. From right to left it shows a Troughed Belt Conveyor from Shake-out, Magnetic Separator, Fume Extraction over Mould Conveyor and Pouring Monorail.

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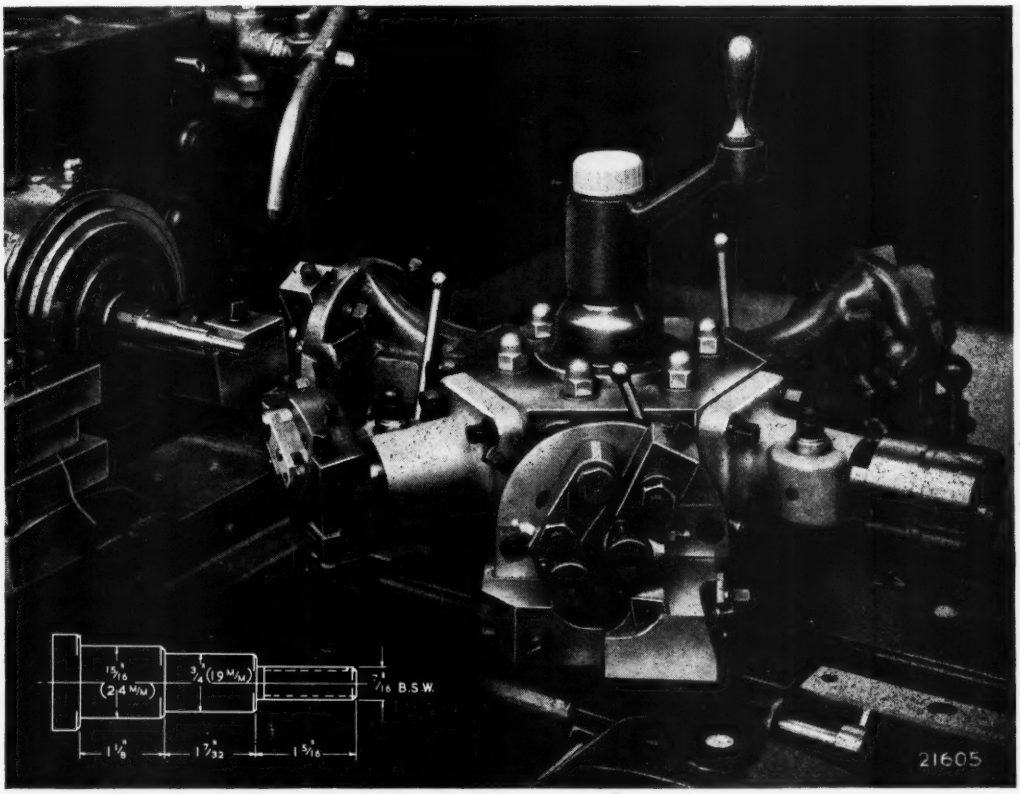

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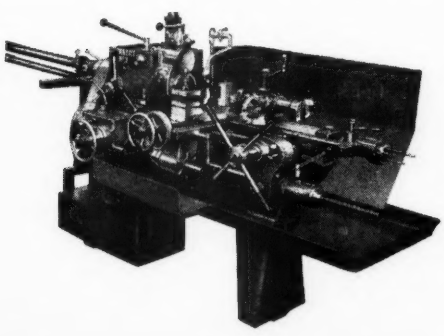

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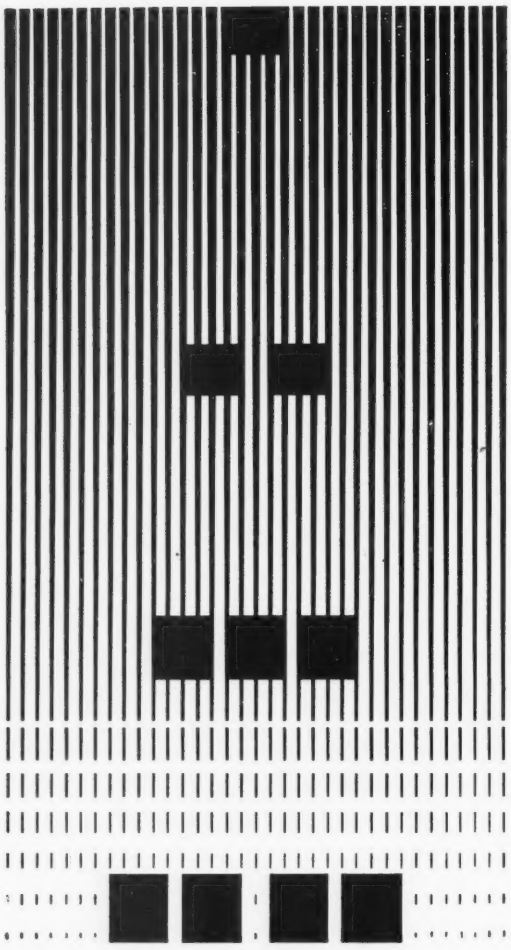

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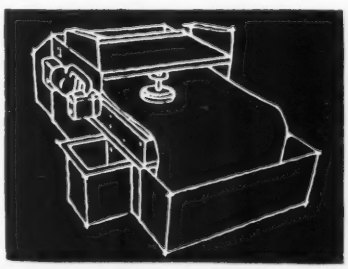

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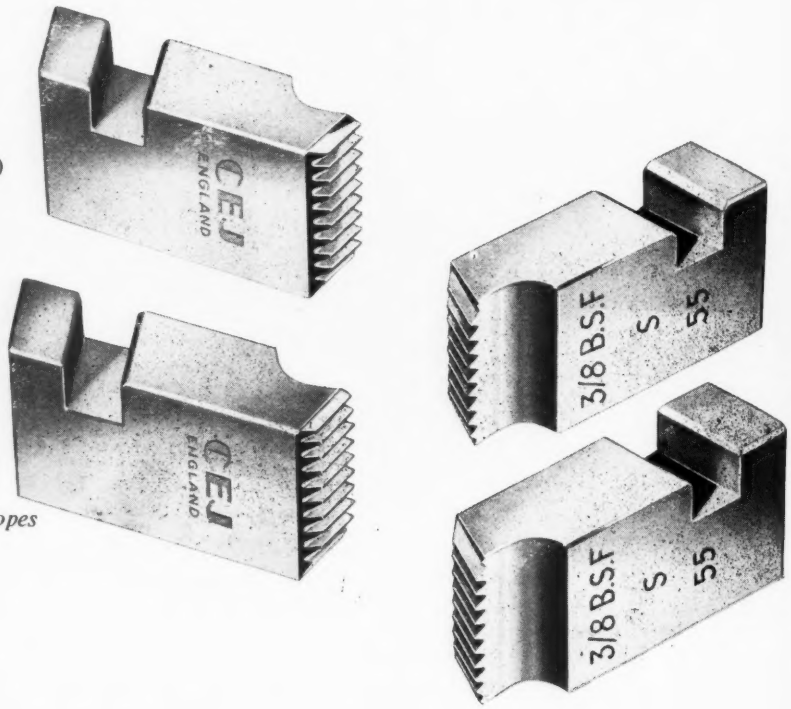
Everything that care and skill can contribute go to ensuring that CEJ Dies will be correct in every detail and fully meet your requirements.

They are manufactured from specially selected H.S.S., correctly heat treated; produced by the most exacting methods, rigidly inspected in all thread elements and actually tested before despatch.

CEJ Chaser Dies can be used in CEJ 430 Die Heads and Coventry and similar type Die Heads.



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Spiral Bevel and Hypoid Gears offer many advantages for right angle drives where high efficiency smooth and silent running are required. E.N.V. specialize in the design and manufacture of straight and curved tooth bevel gears. They offer collaboration with engineers from the project stage on the design of gears and mountings. They have unique facilities for the large-scale manufacture of transmissions including final drives, differentials and axles for vehicles and agricultural equipment, precision gears for aircraft and gears for industrial applications.

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FODENS
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Foden LIMITED
SANDBACH CHESHIRE

2nd May, 57

ADPT/CAM.
EJP/PB/LAB.

Messrs. Glostics Ltd.,
Tuffley Crescent,
Gloucester.

For the attention of Mr. A.D.P. Tallents.

Dear Sirs,

In January 1955 you supplied us with two shot blast nozzles in Carbon Tetra Boride. These were immediately put into use in the shot blast cabinets in our Heat Treatment department, working at an air pressure of 40 to 60 lbs/sq. in., and using 30 mesh angular chilled cast iron grit as the abrasive.

It is estimated that each nozzle has now been in service for more than 5,000 hours, and recent dimensional checks show the amount of wear to be almost negligible. We are advised by you that the original nozzle bore diameter was $\frac{3}{8}$", and it will be seen from the following figures that little, if any, wear has taken place.

Bore Size at Throat of Nozzle .3745" to .3742"
Bore Size 1" from Throat .3650" to .3648"

We feel that an outstanding performance such as this should not go unnoticed, and you are therefore at liberty to use the information contained in this letter in any way you wish to further the publicising of C.T.B. nozzles.

Yours faithfully,
for FODENS LIMITED.

E.J. PHIPPS,
CHIEF METALLURGIST.

This company has no connection whatsoever with any other company making commercial vehicles.

C.T.B SHOT BLAST NOZZLES

Glostics Ltd

AGENTS · IMPREGNATED DIAMOND PRODUCTS LTD · TUFFLEY CRESCENT · GLOUCESTER

SCREW, BOLT or CAVITY FIXINGS

the Speediest way is best!

MODERN BUILDING MATERIALS can be a veritable nightmare to the man who has to deal with the problem of making SPEEDY, PERMANENTLY SECURE FIXINGS having either LIGHT or HEAVY LOADING CAPACITY at an economic cost.

In the RAWLPLUG RANGE there are 21 different types of Fixing Devices, with a tremendous variety of applications. They provide the complete answer to every fixing problem in every kind of material. THE RAWLPLUG RANGE also includes 14 different types of tools for hole boring.

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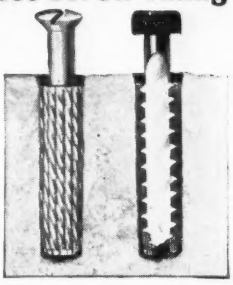
The World's Largest Manufacturers of Fixing Devices

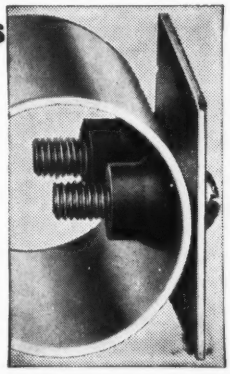
The world's speediest screw fixing

Rawlplugs make firm screw fixings in brick, tiles, cement, stone, etc., in a fraction of the time taken by any other method. Drill the material, insert the Rawlplug, screw up—it's as simple as that! Safe, permanent, and completely reliable in any climate. For all screw sizes up to $\frac{3}{4}$" coach screws.



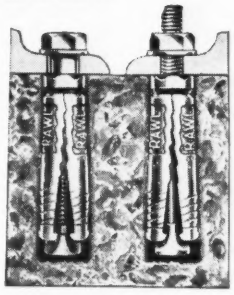
For Cavity fixings

For almost impossible jobs use the Rawlnut. (You can even make a fixing to a pipe). The tapped nut in the end of the rubber bush is drawn up to the reverse face of the material by turning the screw. The result is an airtight, watertight, vibration-proof fixing of enormous strength. For thin plastic, metal, wallboard and hollow pot, etc., it is invaluable.



Bolt it down in minutes!

For light or heavy bolting jobs, no other method even *begins* to approach Rawlbolts for strength, ease and speed. Rawlbolts are a *dry* fixing, they grip at once by expansion—no cold chiselling, no grouting in, no waiting for cement to harden. In all bolt diameters up to 1" in either loose bolt or bolt projecting types.



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For Speed and Strength!

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We are currently fulfilling long and short-run contracts for many nationally-known manufacturers, involving presswork up to 400 tons, spinning, welding, fabrication, finishing and complete assembly of a very wide range of articles. We cordially invite you to come and see us in action, and judge our capacity and standards for yourself.

"... give it to Adams Bros. & Burnley."

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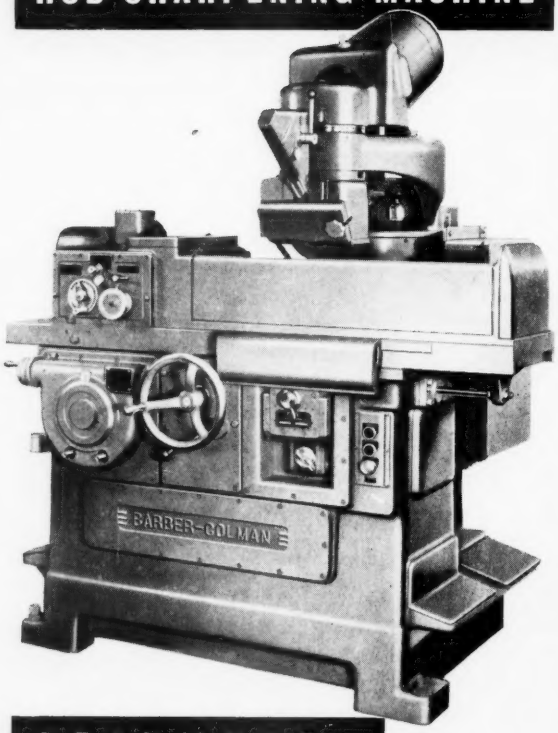
THE NEW

BARBER & COLMAN 6-5 Hydraulic

HOB SHARPENING MACHINE



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- ★ AUTOMATIC FEED AND INDEX COUNTING
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The new Barber-Colman No. 6-5 Hydraulic Sharpening Machine is a precision machine which controls index spacing, rake angle, lead of gash, and surface finish of the cutting tool to a degree which has never before been reached by any commercial sharpening equipment. Illustrated literature available on request.

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Wool washing machinery;
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High quality bricks.

BUT 9296

ORE and ADMIRATION

Steelmen, however old, never fail to feel—no matter how many times they've seen it—the awe and excitement of a furnace in full blast. From apprentice to Chief Smelter, that amazingly skilled aristocrat of the foundries, the thrill remains as sharp as ever with the sweat and heat and glory of it all.

It is well known by steelmen that high purity oxygen in blast, Bessemer or open hearth makes for considerably greater heat much more cheaply. This oxygen is best produced by Butterley on-site Tonnage Oxygenerators and allows a still wider range of quality steels.

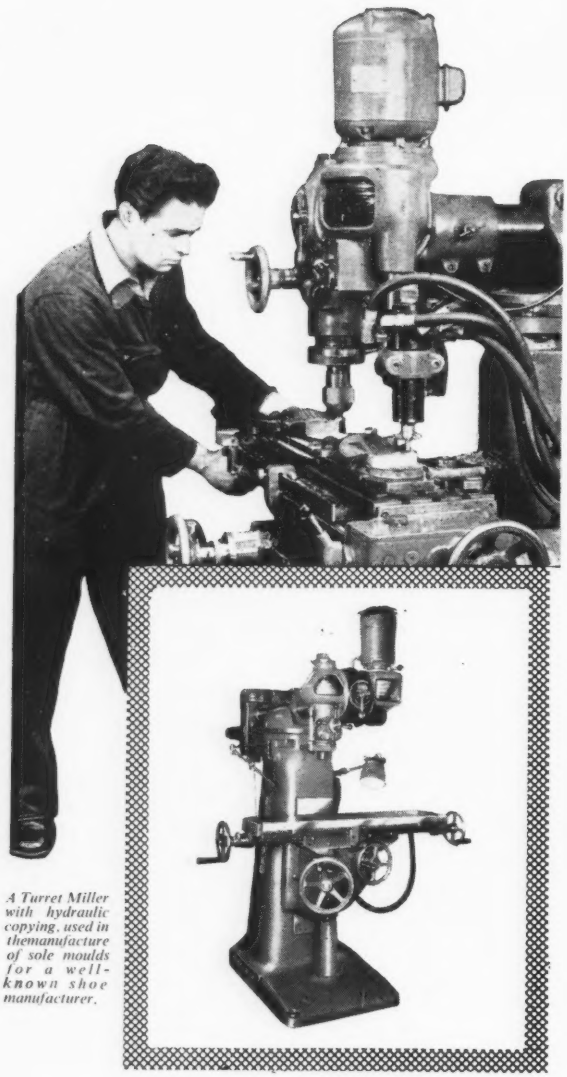
While being compact and efficient, these plants produce a continuous supply of oxygen and/or nitrogen at any desired purity and pressure at any quantity needed where there's work with oxygen afoot.

Sole production and sales rights have been acquired by Butterley from America for U.K., British Commonwealth and certain European countries. If you can use oxygen, consult Butterley Oxygen Division.

If you can use Oxygen, consult

BUTTERLEY
OXYGEN DIVISION

Oxygen Division, The Butterley Company Limited, 9 Upper Belgrave St., London, S.W.1. Tel: SLOane 8172/3



A Turret Miller with hydraulic copying, used in themanufacture of sole moulds for a well-known shoe manufacturer.

RICHMOND

TURRET MILLING MACHINE

FOR CRITICAL ACCURACY — with utter reliability

Table surface 38″ × 9″; 24″ longitudinal, 9″ cross, 14″ vertical traverses. Eight spindle speeds 130 - 4,100 r.p.m. Automatic hydraulic tracer controlled model copies patterns to high degree of accuracy by synchronised movement.

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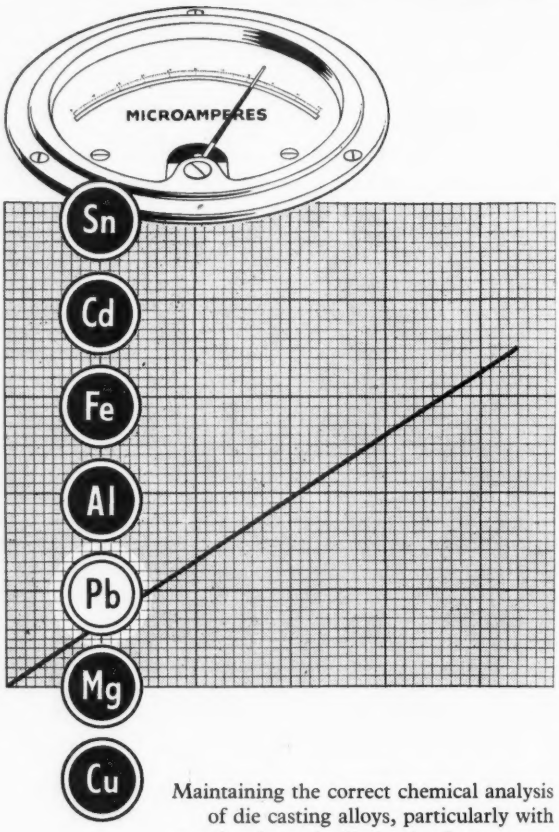
QUALITY CONTROL of pressure die castings



Maintaining the correct chemical analysis of die casting alloys, particularly with regard to impurity limits, is of paramount importance in the production of high quality die castings. Our Laboratory is equipped with one of the few *direct reading spectrographs* in use in this country. As a result the requirements of the B.S.I. Certification Scheme for zinc alloy die castings are far exceeded. Every melt is analysed and the holding furnace of every machine is checked for impurities at least once per shift, enabling any variance from specification to be quickly identified. With the utmost confidence, we can therefore claim to supply castings only of the highest quality.

Quotations, without obligation, from drawings, specifications or samples.

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IN ZINC, ALUMINIUM AND SOFT ALLOYS

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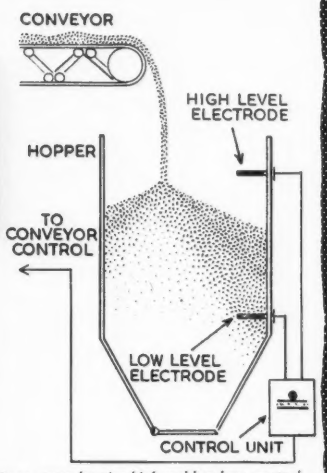
Tottenham, London, N.17

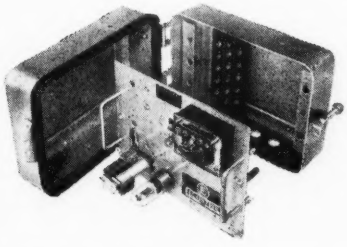
ELCONTROL

level controls

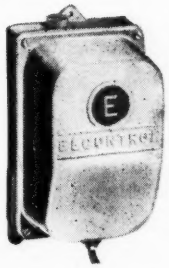
for solids and liquids



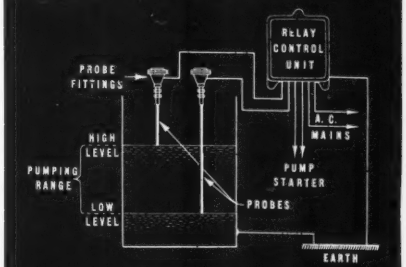
Two electrodes give high and low level control via the relay unit, which controls the conveyor.



LR2 level control unit for liquids with withdrawable chassis.



CR2 proximity switch unit for solids, in robust cast case.



Automatic pump or valve control is provided by contact between liquid and probe tip.

Solid level control ? Yes ! The new Elcontrol proximity switches provide automatic level control for free flowing solids and non-conductive liquids (e.g. oils). The control units are simple and robust and there is a choice of standard electrodes (probe and plate types) which suit most industrial applications.

Elcontrol liquid level controls are usually fitted where conductive liquids — water, condensate, chemical liquids, etc. — are being dealt with.

Complete installations range from approximately £20 upwards.

Electronic control of levels is only one of our activities. We also supply electronic process and cyclic timers, photoelectric equipment, flame failure units and many others.

The CLE4 electrodes as used with the CR2 proximity switch for solids level control.

CLE6 electrode is a plate type unit for fitting into the wall of a hopper, where fairly bulky materials are being handled.

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"—well over 1,000,000 lifts without sign of deterioration"

COMPRESSION MOULD in Doub e-Six steel for making motor starter control knobs from wood-filled phenolic powder. Hardened and tempered to Rockwell 57 "C" scale. Production 10,000 to date, at temperature of 340–380 F.
(By courtesy of Messrs. Brood Motors Ltd., Huddersfield.)

This is what a die-user says of dies similar to that illustrated, which was made from DOUBLE-SIX Super Steel, for dies for plastic moulding.

Edgar Allen have given special attention and much research in conjunction with manufacturers of plastics to the development of the most suitable steels for dies for both moulds and master hobs. From the many available types and compositions they have chosen six steels suitable for moulds, and two for master hobs; from this range you are assured of a steel correct and economical for every duty in plastics manufacture.

MOULD STEELS

A13 : for general use for cut moulds; capable of being hobbed with shallow impressions.

A100 : similar to A13, but cannot be hobbed.

Edgar Allen Plastic Hobbing Steel : for general-purpose hobbing steel for all types of impression.

Imperial R.I.O. Stainless Hobbing Steel : a special steel for moulds produced by the hobbing process, for use with urea and other staining powders.

Imperial Stainless Mould Steel : stainless, but not suitable for hobbing.

Double-Six Die Steel : for moulds required to be hard throughout, but not subject to rough handling; suitable also for injection moulds.

MASTER HOB STEELS

Double-Six Steel : non-shrinking, through-hardening.

Imperial Oil Hardening Steel : dense structure, high compressive strength.

For full information on the selection and treatment of steels for plastics manufacture, write for Publication No. 41A.

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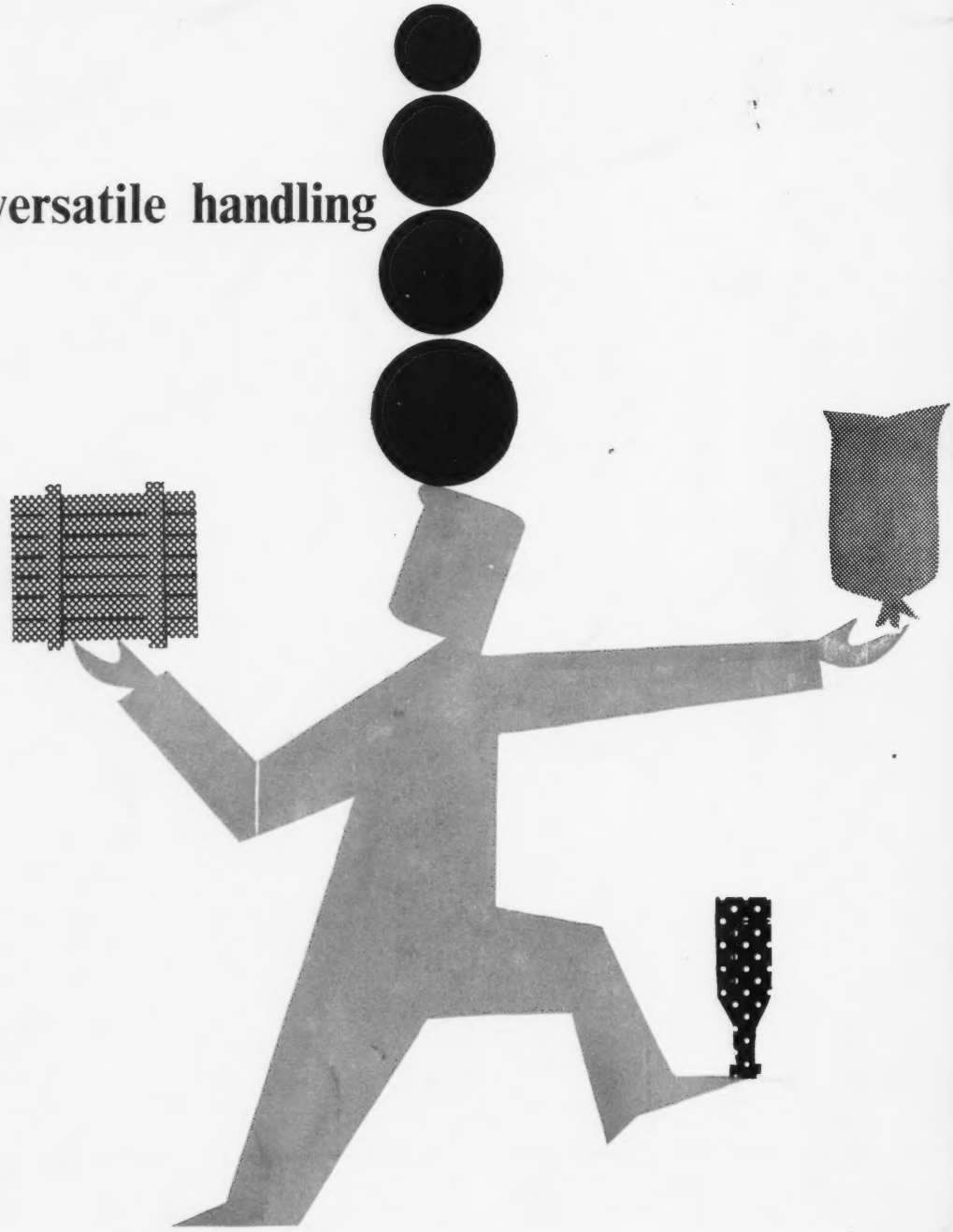

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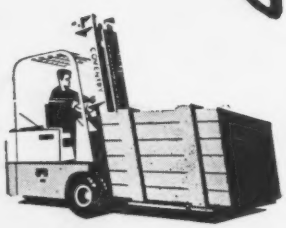

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